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CODEX ALIMENTARIUS COMMISSION

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**Agenda Item 13** **CX/CF 14/8/13(Rev)**
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**JOINT FAO/WHO FOOD STANDARDS PROGRAMME**

**CODEX COMMITTEE ON CONTAMINANTS IN FOODS**

**Eighth Session**
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# DISCUSSION PAPER ON THE DEVELOPMENT OF A CODE OF PRACTICE FOR THE PREVENTION AND REDUCTION OF ARSENIC CONTAMINATION IN RICE

**(Prepared by the Electronic Working Group chaired by China and co-chaired by Japan)**

## BACKGROUND

1. The 7th session of the Committee on Contaminants in Food (CCCF) (April 2013) discussed possibility to develop a code of practice (COP) for the prevention and reduction of arsenic (As) contamination in rice based on some discussion points recommended in para. 105 of a discussion paper presented at that session (CX/CF 13/7/14).

2. While the CCCF generally supported development of a COP, it could not reach agreement on the development of the COP at that stage. The CCCF noted that more information on readily available risk management measures that could be generally implemented by countries across regions, needed to be identified before proceeding with the development of the COP. In order to facilitate the development of the paper, members were encouraged to conduct research and field studies and to provide information.

3. The CCCF agreed to re-establish an electronic working group (EWG) led by China and co-chaired by Japan to further develop the discussion paper, and to look into management practices identified in the discussion paper to determine which risk management measures were readily available to the extent that they could provide the basis of the preliminary development of a COP, and, if so, to attach a proposed draft COP for consideration by the 8th session of the CCCF (REP13/CF, paras 104-107).

4. The discussion paper was developed utilizing fully the data/information provided by Australia, Brazil, Canada, China, Indonesia, Japan, Kenya, Philippines, Singapore, Thailand, USA and FoodDrinkEurope, and taking comments from Australia, Canada, Indonesia, Philippines, UK, USA and FoodDrinkEurope into consideration. The supportive information is contained in Appendix IV and a list of participants of the EWG is presented in Appendix VI.

5. The terms of reference (TORs) of the EWG are:

A) To collect information in relation to management practices identified in para. 104 in CX/CF 13/7/14;

B) To determine which risk management measures are readily available to the extent that they could provide the basis of the preliminary development of a COP; and

C) To attach a proposed draft COP for consideration by the 8th session of the CCCF, if possible.

6. In para. 33 of CX/CF 13/7/14, following four measures were identified as items that can be included in the scope of the COP. Since this discussion paper focused its discussion on the first three measures, "monitoring of effectiveness of measures" was not included in the main text of this discussion paper. However, in order to meet the above mentioned TOR C), the EWG included the text related to "monitoring of effectiveness of measures" in the proposed draft COP which is attached as Appendix III:

- Source directed measures;
- Agricultural practices;
- Processing and cooking; and
- Monitoring of effectiveness of measures.

7. The Committee is invited to consider the conclusions and recommendations in Appendix I in order to decide on new work on the development of a Code of practice for the prevention and reduction of arsenic contamination in rice. In considering the conclusions and recommendations, the Committee is invited to give due consideration to the information contained in Appendix II.

**APPENDIX I**

**DEVELOPMENT OF A CODE OF PRACTICE FOR THE PREVENTION AND REDUCTION OF ARSENIC CONTAMINATION IN RICE**

**CONCLUSIONS**

1. Based on all the available data and information, source directed measures and measures on processing and cooking were identified to be readily available risk management measures for preventing and reducing As concentration in rice.

2. For agricultural measures, various data supported that measures related to control of irrigation water and selection of cultivars are readily available risk management measures for preventing and reducing As concentration in rice. However, for measures related to the use of soil amendments and fertilizers, there were only insufficient data and information available to support the effect of using these materials. Further studies are needed in this area in order to include them in a COP.

3. In this regard, the EWG concluded that there are risk management measures that are readily available to the extent that they would provide the basis of the preliminary development of a COP.

4. Therefore, the EWG developed the draft COP as attached (Appendix III) for consideration by the 8$^{th}$ session of the Committee.

5. The EWG noted that the results of the ongoing or further research and studies on the effect of the measures to prevent and reduce As concentration in rice should be included in the COP if time allows and noted that the following research and studies may be supportive in developing better COP:

- Effects of the soil amendments and fertilizers (e.g. silicates, phosphates and organic materials) on As concentration in rice, where possible, with applying different amount of the materials, or applying the materials in different timing and frequency (e.g. one-off or repeatedly use in each season);
- Duration of effect of the soil amendments and fertilizers on As concentration in rice with applying them for once or multiple times to a soil;
- Side effects (e.g. change of yield, Cd concentration in rice) of implementing the measures to reduce As concentration in rice;
- Effect of applying flooded/aerobic condition with different timing and duration in rice growth period;
- Estimation of As concentration in rice from the As concentration in soil and/or other factors affecting As concentration in rice (e.g. iron, silicates, phosphates etc.) before the cultivation; and
- Efficiency and cost of removing As in soil using agricultural crops other than rice that absorbs and accumulates As greatly from the soil and chemical compounds which absorb As greatly and are easily separated from the soil.

**RECOMMENDATIONS**

6. Based on the above conclusions, the EWG recommended that the CCCF should:

(a) submit a project document for the development of a COP for the prevention and reduction of arsenic in rice” as a proposal for new work;

(b) use the attached draft (Appendix I) including the measures identified in the discussion paper as a basis for the COP;

(c) encourage the Members to conduct further research and studies on the effect of the measures to prevent and reduce As concentration in rice. And also encourage to share the results of these research and studies among Members;

(d) note that the research and studies in para. 5 were identified by EWG as supportive in developing better COP; and

(e) if time allows, try to consider and include the results of the ongoing research during the development of the COP.

**APPENDIX II**

**MANAGEMENT MEASURES FOR THE DEVELOPMENT OF A CODE OF PRACTICE FOR THE PREVENTION AND REDUCTION OF ARSENIC CONTAMINATION IN RICE**

## SCOPE

Management measures

1. In accordance with the TOR, the following three types of management measures described in CX/CF 13/7/14 will be considered in this paper:

A) Source directed measures;

B) Agricultural measures (use of soil amendments and fertilizers, control of irrigation water and selection of cultivars); and

C) Measures on processing and cooking.

2. The data/information provided in response to the first and second data/information calls and the latest scientific knowledge are summarized in Appendix IV and used as a basis for discussion.

Forms of As

3. The Codex COP is intended to provide guidance to Members on prevention and reduction of inorganic Arsenic (iAs) in rice. Inorganic As is classified as a known human carcinogen by the IARC[1]. It may be useful to monitor total arsenic (tAs) in rice as a screening tool for iAs because analyzing tAs is easier than iAs and in most cases the reduction of tAs correlates with the reduction of iAs (see Tables 2:1-2, 3:1-5 and 3:7 in Appendix IV).

4. Although the focus of a COP should be iAs in rice, the effects of interventions on tAs and other forms of As (MMA and DMA) can also be considered because of the issues such as follows:

- For both inorganic and organic As and four species of As (i.e. arsenite, arsenate, MMA and DMA), kinetics and biochemical aspects of absorption, transformation, translocation and accumulation in air, soil, water and rice plant are revealed to some extent but still need further studies; and
- Validated analytical methods (preferably internationally) for the four species of As in soil and rice plant are essential for estimating the risk from iAs in food and checking the effectiveness of measures taken. While some analytical methods have been internationally validated through collaborative studies for these As compounds in rice, methods for the same in soil and rice plant are being validated.

## DEFINITIONS

5. In this paper, the following definitions are used:

***Rice grain*** (paddy rice) is rice which has retained its husk after threshing (GC0649[2]).

***Husked rice*** (brown rice or cargo rice) is rice grain from which the husk only has been removed. The process of husking and handling may result in some loss of bran (CM 0649[2]).

***Polished rice*** (milled rice or white rice) is husked rice from which all or part of the bran and germ have been removed by milling (CM 1205[2]).

***Flooded condition*** means the condition that a paddy field is filled or covered with water.

***Aerobic condition*** means the condition that a paddy field is more aerobic than flooded condition.

***Intermittent ponding*** means condition that a paddy field is alternately in flooded and aerobic condition.

## DISCUSSION POINTS

Source directed measures

6. Arsenic is a naturally occurring element and is found throughout the world. Arsenic can be emitted and released to air, water and land. Arsenic is naturally contained in soil of paddy fields. Arsenic comes into paddy fields mainly from irrigation water, rain, air and use of soil amendments and fertilizers[3] containing As. Arsenic will be absorbed from soil pore water in paddy fields and accumulated in rice. Therefore, as the environment (i.e. air, soil, water) is the source of As in rice, measures to control supply pathway of As into paddy fields would contribute in reducing As in rice.

[1] http://monographs.iarc.fr/ENG/Monographs/vol23/volume23.pdf
[2] Classification of Foods and Animal Feeds (CAC/MISC 4-1993)
[3] "Soil amendments and fertilizers" include sewage sludge, hereinafter the same.

7. Source directed measures for prevention and/or reduction of As in rice may include control and/or regulation of As in air (ambient air and exhaust gas), water (natural water, liquid waste and irrigation water) and soil (soil of agricultural land). In addition, regulating the production, sale, use and disposal of materials used in agriculture and livestock production which may contain As (e.g. pesticide, veterinary medicine, feed additive, feed, soil amendment and fertilizer, timber production/waste, other waste) may also be potential source directed measures.

8. The above mentioned measures fall under the scope of the *Code of Practice for Source Directed Measures to Reduce Contamination of Food and Feed with Chemicals* (CAC/RCP 49-2001). In particular, the following general measures in CAC/RCP 49-2001 are potentially appropriate for prevention/reduction of As in rice:

A) Controlling emissions of pollutants from industry e.g. the chemical, mining, metal and paper industries;

B) Controlling emissions from energy generation (including nuclear plants) and means of transportation;

C) Controlling the disposal of solid and liquid domestic and industrial waste, including its deposition on land, disposal of sewage sludge and incineration of municipal waste;

D) Controlling the production, sale and use and disposal of certain toxic, environmentally-persistent substances;

E) Replacing toxic environmentally-persistent substances by products which are more acceptable from the health and environmental points of view; and

F) Blacklisting areas of concern, i.e. prohibiting the sale of foods and feeds derived from these polluted areas where agricultural land is heavily polluted due to local emissions, and/or remediating this pollution.

9. As-specific source directed measures are implemented in all of eight Members that have provided information to this EWG. All the eight countries established MLs or GLs of tAs for either one, two or all of air, water and soil (see Table 1:1 in Appendix IV). Six of them have implemented some measures in relation to materials used in agriculture and livestock production, and all of them established MLs or GLs for tAs in the soil amendments and fertilizers (see Table 1:2 in Appendix IV). Some Members provided reasons for implementing the measures. No information was available for not implementing any measures.

10. At the 7th session of the CCCF, one Member shared its experience in implementing As-specific source directed measure, which is to add ferric iron material to settling tanks or channels or growing hyper accumulator plants in settling tanks as shown in CF/7 CRD13.

11. If a country has a wide range of its land and/or water contaminated with As, it may have concerns on technical, economic or food-security feasibilities for implementing source directed measures. The provided information on source directed measures indicate that Members are choosing the feasible and effective measures applicable mostly to air, water, soil and/or materials used in agriculture and livestock production.

12. The measures contained in CAC/RCP49-2001 can generally be used as source directed measures for prevention and/or reduction of arsenic in rice. However, as some Members are using more As-specific source directed measures, CAC/RCP49-2001 may be too general to be used for prevention/reduction of As in rice and in the surrounding environment. A COP including these As-specific source directed measures would provide a more useful and effective guidance for the governments.

13. As certain Members from different regions are implementing As-specific source directed measures according to their environmental conditions, risk management measures to control and regulate air, water, soil and materials used in agriculture and livestock production which are readily available to the extent that could provide the basis for the preliminary development of a COP.

14. In response to the question regarding including source directed measures in a COP, five out of six Members responded supported including source directed measures in a COP. One Member was of the opinion that the identified source directed measures are not relevant to the direct reduction of As in rice. Another Member was of the opinion that the effect of the identified source directed measures need to be supported by validated data.

15. In response to the question whether the CCCF should revise the CAC/RCP 49-2001 or develop an As-specific COP to include As-specific source directed measures, all six Members responded supported the latter option.

16. In conclusion, in order to provide more useful guidance on source directed measures regarding As, the EWG decided to recommend the CCCF to include As-specific source directed measures in a COP. The EWG noted that the CAC/RCP 49-2001 is essential backbone for the development of the mentioned measures but should remain as a general COP document for all chemicals.

Agricultural measures

17. Most of discussions at the last session of the CCCF were based on the results of pot studies and concrete frame experiments. However, in order to determine which agricultural measures are practically available in the field, the EWG was asked by the CCCF to base its discussion on science supported by field studies (see para. 105 of REP13/CF). In this regards, the EWG focused its discussion on the data and information obtained from the field studies.

A) For measures related to the "use of soil amendments and fertilizers"

18. Information on field studies was collected on the use of the soil amendments and fertilizers indicated in CX/CF 13/7/14 (those listed below) and others which may affect the concentration of As in rice.

- Iron-containing materials;
- Phosphates;
- Silicates; and
- Organic materials.

19. Two field studies were available on the use of iron-containing materials. According to these studies, using iron-containing materials reduced the concentration of As in rice by up to 40% (see Table 2:1 in Appendix IV).

20. One field study showed that application of a non-reducible sorbent (alum) could reduce As solubilization and uptake by rice. However, due to the high cost of alum, it would not be a cost effective soil amendment to reduce As uptake by rice.

21. In addition, one Member reported that there were studies currently underway to find out:

- effects of various soil nutrient concentrations on organic/inorganic As concentrations in soil, grain, and straw;
- changes in soil chemistry as a result of organic or conventional management practices related to As accumulation in rice; and
- how different rates and organic fertilizer amendments impact soil chemistry and As concentration in rice.

22. Some countries are studying on the effect of using Phosphates, Silicates, and Organic materials in the fields. However, no information or data regarding the effects of applying these materials in the field have become available for inclusion in this paper.

B) For measures related to "control of irrigation water"

23. Following data and information on field experiments were used as basis for the discussion in this Section:

- data provided by one Member after the 7$^{th}$ CCCF;
- scientific papers recently published in addition to CX/CF 13/7/14; and
- those indicated in CX/CF 13/7/14.

24. The results of all the above mentioned studies showed that As concentration in rice increased in the flooded condition, and decreased in the aerobic soil condition and intermittent ponding condition. The results showing the same trend were obtained from the studies conducted in rice-producing countries in different regions using *japonica* and/or *indica* rice (see Table 2:2 in Appendix IV).

25. At the last session, concerns were raised regarding conditions that adversely affect rice yield. Rice grown under aerobic soil condition tends to contain lower concentrations of As. However, at the same time, it is said that rice yield decreases when aerobic conditions are applied for a long time in a rice growing period. For examples, a study showed strong yield reduction along with reduction in grain tAs (see Table 2:2 in Appendix IV). On the other hand, according to the other studies, by applying aerobic conditions for an appropriate duration and controlling the water content of soil in the field, rice yield can be sustained or even increased with lower tAs concentration in rice compared with those in rice grown under flooded conditions (see Table 2:2 in Appendix IV).

26. When paddy soil is potentially contaminated with both As and cadmium (Cd), it is important to note that special attention must be given regarding the control of irrigation water. Growing rice under aerobic condition is effective in reducing As concentration in rice. However, aerobic condition contributes to the increase of Cd concentration in rice (see Table 2:2 in Appendix IV). This proves that measures based on control of irrigation water alone are incapable of reducing concentrations of both As and Cd in rice at the same time. In order to solve this problem, studies have been conducted in Japan on rice cultivars. The identified rice cultivars(1, 2), which, when transplanted in soil highly contaminated with Cd, do not incorporate Cd under aerobic condition. These studies show the potential for identifying cultivars that do not take up Cd when grown under aerobic conditions.

C) For measures related to "selection of cultivars"

27. In order to see if different rice cultivars contain different concentrations of As in grain, the results of field studies using various cultivars in CX/CF 13/7/14 and those provided by one Member are compiled in Table 2:3 in Appendix IV.

28. The compiled information indicate the same conclusion as described in CX/CF 13/7/14. There is a significant genetic diversity in As uptake by rice plants and in translocation of As into rice grain. Nonetheless, other factors such as the environment, location, flooding management and genotype-environment interaction can also significantly influence As concentration in rice grain.

29. In any region, there are some cultivars that contain lower arsenic in grain than others under the specific agricultural condition. These cultivars can be selected by using scientific papers for similar agricultural conditions in Table 2:3 in Appendix IV.

30. In conclusion for A) to C) above, there is sufficient information for readily available measures related to "control of irrigation water" and "selection of cultivars" to be included in a COP. In response to the question regarding inclusion of these agricultural measures in a COP, all Members who provided their comments to the EWG supported this conclusion.

31. As it may be difficult for farmers to select rice cultivars that yield rice grain containing As at low concentrations, the COP may include advice to governments to encourage public research institute and/or private nursery developer to develop rice cultivars that yield grain with low As as one of the options for a government to choose. A Member was of the opinion that this recommendation should not be included in a COP as an agricultural measure but can be placed in the introductory section of a COP.

Measures on processing and cooking

32. Both tAs and iAs concentrations in rice decrease by milling husked rice. Based on more than 8000 data points provided by Members, the mean tAs and iAs concentrations were calculated for husked and polished rice. The mean concentration of tAs in polished rice was approximately 40% lower than that in husked rice in both *indica* and *japonica*; and the mean iAs concentration in polished rice was approximately 50% lower than that in husked rice in *indica* and 40% in *japonica* (see Table 1 below and Table 3:1 in Appendix IV).

**Table 1 Comparison of the mean concentrations of total and inorganic As**

| | Husked rice(mg/kg) | | Polished rice(mg/kg) | | Reduction (%) | |
|---|---|---|---|---|---|---|
| | Total As | Inorganic As | Total As | Inorganic As | Total As | Inorganic As |
| *indica* | 0.23 | 0.17 | 0.14 | 0.09 | 39 | 48 |
| *japonica* | 0.20 | 0.17 | 0.13 | 0.11 | 35 | 35 |

33. Three studies were available investigating reduction of As concentration of rice obtained from the same lot by milling. In these studies, both tAs and iAs concentrations decreased by approximately 40% by milling husked rice (see Table 3:2 in Appendix IV). One study shows that the more husked rice is polished, the more the concentrations of tAs and iAs decrease (see Table 3:3 in Appendix IV).

34. Some studies show that washing/rinsing is another effective process of decreasing As in rice. Two studies show that As concentration was reduced by washing husked or polished rice with water (see Table 3:4 in Appendix IV). Usually rice is washed using clean water before cooking to remove remaining bran on the surface of rice. In a number of countries, with a number of techniques, bran on the surface is completely removed to make rice "wash-free" or "cooking-ready" without washing. Since this type of rice does not contain bran at all and the rate of milling (87-88% of husked rice) is slightly greater than conventional milling (ca. 90% of husked rice), the As concentration is also lower than that in conventionally polished rice (Table 3:3).

35. For the effect of cooking on As concentration in water, four studies are available. These studies show that decrease of As concentration depends heavily on the As concentration of water used for cooking. When rice is cooked with a large amount of clean water (i.e., not contaminated with As) followed by discarding excess cooking water, the As concentration of cooked rice decreases from that in uncooked rice. When As-contaminated water is used for cooking, the As concentrations of cooked rice increase (see Table 3:4, 3:5 and 3:6 in Appendix IV). Cooking rice in excess amount of contaminated water further increases the arsenic content of rice even when the excess water is poured out (3).

36. For both in cooking and washing processes, using a large amount of non-contaminated water and subsequent thorough draining of excess water are proved to be effective in reducing the iAs and tAs concentrations in cooked rice. When washing and cooking rice, use of water that is highly contaminated with As must be avoided.

37. Husked rice serves as a source of nutrients such as iron, magnesium, selenium, B vitamins, and dietary fibre. Ingestion of husked rice may reduce the risk of such conditions as cardiovascular disease, overweight and type 2 diabetes (USDA/HHS, 2010). Therefore, while it is important to note that choosing polished rice would contribute to the reduction of As intake, choosing polished rice would result in the loss of the above mentioned nutrients.

38. In conclusion, various data supported that milling, and washing and cooking with non-contaminated water are readily available risk management measures for effectively reducing As concentrations in processed and cooked rice. In response to the question regarding including measures on processing and cooking in a COP, all Members provided their comments supported this conclusion.

39. As the above mentioned actions would be mainly taken by processers and consumers, sharing information on these identified risk management measures along with risk and benefit of consuming polished or husked rice among stakeholders is considered to be additional possible risk management measures to be included in the COP.

**APPENDIX III**

**CODE OF PRACTICE FOR THE PREVENTION AND REDUCTION OF ARSENIC CONTAMINATION IN RICE**

**(Proposed Draft Outline)**

## INTRODUCTION

1. Arsenic is described as a metalloid because it displays properties intermediate of these typical for metals and non-metals. According to the JECFA evaluation for inorganic arsenic in food, 1) the lower limit on the benchmark dose for a 0.5% increased incidence of lung cancer ($BMDL_{0.5}$) was determined from epidemiological studies to be 3.0 μg/kg bw per day (2.0-7.0 μg/kg bw per day based on the range of estimated total dietary exposure); and 2) drinking-water was a major contributor to total inorganic arsenic dietary exposures and, depending on the concentration, can also be an important source of arsenic in food through food preparation and possibly irrigation of crops, particularly rice.

2. Arsenic is naturally contained in soil of paddy fields. Arsenic can be also emitted and released to air, water and land and comes into paddy fields from irrigation water, rain, air and use and disposal of materials used in agricultural and livestock production containing arsenic. Rice plants absorb arsenic from soil especially in reductive conditions and accumulate arsenic in grains and straws. Arsenic forms in rice are inorganic arsenic (arsenite and arsenate) and organic arsenic (monomethylarsonic acid and dimethylarsinic acid).

3. Although the best practices for the prevention and reduction of arsenic contamination in rice should focus on inorganic arsenic, it may be useful to monitor total arsenic in rice as a screening tool for inorganic arsenic as analyzing total arsenic is easier than inorganic arsenic and in most cases the reduction of total arsenic correlates with the reduction of inorganic arsenic.

4. Sources of arsenic in the environment are: 1) volcanic action, low-temperature volatilization, elution from soil or sediment such as the Holocene sediment and geogenic weathering origin either due to soil formation from local bedrock or from sediment carried in from upstream as natural sources; and 2) disposal of timber treated with copper chrome arsenate, use of arsenic pesticides, emission from industries especially for mining and smelting of non-ferrous metals, burning of fossil fuels and large population center as non-point source industrial/urban pollution as anthropogenic sources. In the paddy environment, use of soil amendments and fertilizers contaminated with arsenic are also sources of arsenic[1].

5. Arsenic concentration in rice should be as low as reasonably achievable through best practices such as source directed measures, good agricultural practices, good manufacturing practices and other relevant practices.

6. When applying the Code for rice, measures should be carefully chosen from the viewpoint of feasibility, benefits, effectiveness and food security. Especially for the agricultural measures, since effects of agricultural measures to reduce arsenic concentration in rice are largely influenced by the environmental conditions (e.g. soil condition, temperature) and combination with other measures, its effectiveness and feasibility should be tested by field studies before implementing the measures.

7. Effectiveness of applying the measures for prevention and reduction of As contamination in rice should be monitored by appropriate ways. If agricultural land or ground waters are widely contaminated by natural sources, non-point source or past activities, monitoring arsenic concentrations in soil and/or irrigation water is necessary.

8. The results of ongoing or further studies and research on the effect of the measures to prevent and/or reduce arsenic contamination in rice would be available to develop and improved this COP. Especially, the use of soil amendments and fertilizers has potential effects to reduce/increase arsenic in rice from the results in several pot experiments. The field studies about agricultural measures including the effects on soil amendments and fertilizers are conducted in regions.

9. This COP should be revised periodically taking implementation status in each country, the effect of the measures for prevention and reduction on arsenic concentration in rice, and results of the ongoing or further studies and research on the effect of the measures to prevent and reduce arsenic contamination in rice.

## SCOPE

10. This Code of Practice intends to provide national and local authorities, producers, manufacturers and other relevant bodies with all possible guidance to prevent and reduce arsenic contamination in rice. The guidance covers three strategies (where data and information are available) and monitoring the effectiveness of measures:

i. Source directed measures;

ii. Agricultural measures;

iii. Processing and cooking measures; and

iv. Monitoring.

11. The agricultural measures consist of “control of irrigation water” and “selection cultivars” at this moment because of data/information availability. Measures on “use of soil amendments and fertilizers will be added in this document if data/information to support developing the measures are available in near future.

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[1] Many fertilizers may contain trace levels of arsenic. “Contaminated” should not be interpreted as equivalent to trace levels of arsenic.

**DEFINITIONS**

12. In this paper, the following definitions are used:

***Rice grain*** (paddy rice) is rice which has retained its husk after threshing (GC0649[2]);

***Husked rice*** (brown rice or cargo rice) is rice grain from which the husk only has been removed. The process of husking and handling may result in some loss of bran (CM 0649[2]);

***Polished rice*** (milled rice or white rice) is husked rice from which all or part of the bran and germ have been removed by milling (CM 1205[2]);

***Flooded condition*** means the condition that a paddy field is filled or covered with water;

***Aerobic condition*** means the condition that a paddy field is more aerobic than flooded condition; and

***Intermittent ponding*** means condition that a paddy field is alternately in flooded and aerobic condition.

**OUTLINE OF RECOMMENDED PRACTICES**

SOURCE DIRECTED MEASURES

Note: Text should be developed on the basis of paras 9 - 11 in Appendix II including the following text.

[13. Reducing sources of arsenic is important for a further reduction of contamination in the agricultural environments including paddy fields. Sources of arsenic are not only natural origin but also anthropogenic activities. To reduce arsenic contamination in the environment, national food authorities should consider recommending to their authorities responsible for environment, waste, or agricultural materials as follows:

- Irrigation water;
  - Identification of irrigation water with high arsenic concentration
  - Elimination of arsenic from irrigation water with high arsenic concentration
  - Avoidance of using irrigation water with high arsenic concentration for rice production
- Soil;
  - Identification of paddy fields in which arsenic concentration in soil is high and/or rice produced with high inorganic arsenic concentration
- Exhaust gas and drainage water from industries;
- Material used in agricultural and livestock production such as pesticide, veterinary medicine, feed, soil amendment and fertilizer; and
- Waste containing arsenic such as timber treated with copper chrome arsenate.

14. Farmer should avoid using arsenic contaminated water as irrigation water.]

GOOD AGRICULTURAL PRACTICE

[15. Since there are large uncertainties about the extent to which farmers may implement the measures, education of farmers is an important measure to be addressed.]

Control of Irrigation Water

Note: Text should be developed on the basis of paras 24 - 26 in Appendix II including the following text.

[16. Governments should encourage farmers to avoid continuous flooded condition during rice cultivation taking rice yield under consideration.]

Selection of Cultivars

Note: Text should be developed on the basis of paras 28 - 31 in Appendix II including the following text.

[17. Governments should encourage public research institute and/or private nursery developer to develop rice cultivars that yield grain with low arsenic.]

PROCESSING AND COOKING [and CONSUMER] PRACTICES

Note: Text should be developed on the basis of paras 32 - 39 in Appendix II including the following text.

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2 Classification of Foods and Animal Feeds (CAC/MISC 4-1993)

[18. Governments should share information on risk and benefit of consuming polished or husked rice among stakeholders in the light of arsenic concentrations and nutrient components.]

<u>MONITORING</u>

Note: Text should be developed on the basis of paras 97 - 103 of CX/CF 13/7/14 including the following text.

[19. The concentration of arsenic in contaminated paddies and rice and its products should be monitored before and after implementation of countermeasures. If agricultural land or ground waters are widely contaminated by natural sources, non-point source or past activities, monitoring arsenic concentrations in soil or irrigation water is necessary.

20. The effectiveness of source directed measures and agricultural measures should be monitored by arsenic concentrations in rice.]

**<u>COMPLEMENTARY INFORMATION FOR FURTHER CONSIDRATION OF MEASURES</u>**

Note: Text should be developed on the basis of para. 5 in Appendix I including the following text.

[21. The results of the ongoing or further research and studies on the effect of the measures to prevent and reduce arsenic concentration in rice should be considered to develop the COP and the following research and studies may be supportive in developing better COP:

- Effects of the soil amendments and fertilizers (e.g. silicates, phosphates and organic materials) on arsenic concentrations in rice, where possible, with applying different amount of the materials, or applying the materials in different timing and frequency (e.g. one-off or repeatedly use in each season);

  Duration of effect of the soil amendments and fertilizers on arsenic concentrations in rice with applying them for once or multiple times to a soil;

- Side effects (e.g. change of yield, cadmium concentration in rice) of implementing the measures to reduce arsenic concentrations in rice;

- Effect of applying flooded/aerobic condition with different timing and duration in rice growth period;

- Estimation of arsenic concentration in rice from the arsenic concentration in soil and/or other factors affecting arsenic concentration in rice (e.g. iron, silicates, phosphates etc.) before the cultivation; and

- Efficiency and cost of removing arsenic in soil using agricultural crops other than rice that absorbs and accumulates arsenic greatly from the soil and chemical compounds which absorb arsenic greatly and are easily separated from the soil.]

**APPENDIX IV**

**SUPPORTIVE INFORMATION**

CONSIDERTAION OF SOURCE DIRECTED MEASURES

1. Member countries implementing As specific source directed measures

In respond to the information call, relevant information on As specific source directed measures were provided by Brazil, China, Japan, Indonesia, Philippines, Singapore, Thailand and USA.

Table 1:1 Members implementing As specific source directed measures in air, water and soil

| Target | | Environmental Criteria | Legal obligations of emission from industry and/or energy generation | Other management |
|---|---|---|---|---|
| Air | Ambient air | China, Japan | | |
| | Exhaust gas | China, Philippines, USA, | Singapore, Thailand | |
| Water | Natural water | Brazil, China, Japan, Philippines, Singapore | | India |
| | Liquid waste | China, Indonesia, Philippines | Brazil, Japan, Singapore, Thailand | |
| | Irrigation water | Brazil, China, Indonesia, Japan, Philippines, Singapore, Thailand | | |
| Soil of agricultural land | | Brazil, China, Japan, Thailand | | |

Table 1:2 Members regulating the production, sale, use and disposal of materials used in agriculture and livestock production

| Target | Establishment of MLs/GLs | Other management |
|---|---|---|
| Pesticide | | USA |
| Veterinary medicine with medical function | Brazil, China | USA |
| Food additive without medical function | | |
| Feed | China, Japan | |
| Soil amendment and fertilizer* | Brazil, China, Indonesia, Japan, Thailand, USA | |
| Timber | | China (timber usage), Japan (timber disposal), USA(timber usage) |
| Waste other than timber | Japan | |
| Others | | |

* Including sewage sludge.

Source directed measures indicated in CAC/RCP 49-2001 that are relevant to As specific source directed measures implemented by Members (i.e. measures provided in Table 1:1 and 1:2).

Table 1:3: Measures indicated in CAC/RCP 49-2001 and targets of As-specific source directed measures

| Measures indicated in CAC/RCP 49-2001 | Targets of As- specific source directed measures |
|---|---|
| Control emissions of pollutants from industry e.g. the chemical, mining, metal and paper industries | air, water, soil |
| Control emissions from energy generation (including nuclear plants) and means of transportation | air, water |
| Control the disposal of solid and liquid domestic and industrial waste, including its deposition on land, disposal of sewage sludge and incineration of municipal waste | timber, waste other than timber |
| Control the production, sale and use and disposal of certain toxic, environmentally-persistent substances | pesticide, veterinary medicine with medical function, food additive without medical function, feed, soil amendment and fertilizer, others |
| Replace toxic environmentally-persistent substances by products which are more acceptable from the health and environmental points of view | pesticide, veterinary medicine with medical function, food additive without medical function, feed, soil amendment and fertilizer, timber, others |
| Blacklisting the areas concerned, i.e. remediate land pollution and/or prohibit the sale of foods and feeds derived from these polluted areas, where agricultural land is heavily polluted due to local emissions | soil, water |

CONSIDERATION OF AGRICULTURAL MEASURES

A) Use of soil amendment and fertilizers

There were three field experimental studies conducted in China, Japan and USA, showing the effect of reducing As concentration in rice by using iron-containing materials and alum.

Table 2:1: Effect of soil amendments and fertilizers in reducing As concentration in rice.

| Country | *Subspecies* | Water management | Soil amendments and fertilizers | | As conc. in grain | | Ref |
|---|---|---|---|---|---|---|---|
| | | | Variety | Input | Total (mg/kg) | Inorganic (mg/kg) | |
| China | *japonica* | Submersion | No input | 0 | 0.647 | | Z. M. Xie et al.(1998)(4) |
| | | | $FeCl_3 \cdot 6H_2O$ | 25 (mg-Fe/kg-soil) | 0.595 | | |
| | | Drying and wetting | No input | 0 | 0.492 | | |
| | | | $FeCl_3 \cdot 6H_2O$ | 25 (mg-Fe/kg-soil) | 0.474 | | |
| Japan | *japonica* | In each 3 weeks before and after flowering, flooded condition | No input | 0 | 0.39 | 0.31 | Unpublished data |
| | | | iron oxide with silicate | 5.0 (t-Fe/ha) | 0.35 | 0.26 | |
| | | | iron hydroxide | 5.0 (t-Fe/ha) | 0.29 | 0.26 | |
| | | | zero valent iron | 5.0 (t-Fe/ha) | 0.24 | 0.20 | |
| USA | *japonica* | Continuously flooded condition | Alum | 0 (kg/ha) | 0.179 (polished) | | Unpublished data |
| | | | | 560 (kg/ha) | 0.169 (polished) | | |
| | | | | 1120 (kg/ha) | 0.169 (polished) | | |
| | | | | 2240 (kg/ha) | 0.138 (polished) | | |

B) Control of irrigation water

Data of six field experimental studies conducted in India, China, USA, Bangladesh and Japan were available. These studies investigated the effect of controlling irrigation water in reducing As concentration in rice, change of yield and Cd concentration in rice.

Table 2:2: Effect of controlling irrigation water in reducing As concentration in rice and change in yield and Cd concentration

| Country | *Subspecies* | way of irrigation water | Total As conc. in grain (mg/kg) | Inorganic As conc. in rice (mg/kg) | Yield (t/ha) | Cd conc. in grain (mg/kg) | Reference |
|---|---|---|---|---|---|---|---|
| India | unknown | (15-45 days after transplanting) Continuous ponding | 0.56 | | 4.69 | - | S. Sarkar *et al*. (2012)(5) |
| | | Intermittent ponding | 0.42 | | 4.33 | | |
| | | Saturation ponding | 0.53 | | 3.92 | | |
| | | Aerobic condition | 0.46 | | 3.65 | | |
| China | *japonica* | Flooded | *0.48* | | *7.9* | *0.04* | P. Hu *et al*.(2013)(6) |
| | | Flooded and intermittent | *0.30* | | *10.2* | *0.12* | |
| | | Intermittent | *0.22* | | *10.0* | *0.76* | |
| | | Aerobic | *0.24* | | *8.4* | *1.12* | |
| | *japonica* | Flooded | *0.30* | | *9.1* | *0.08* | |
| | | Flooded and intermittent | *0.27* | | *9.8* | *0.20* | |
| | | Intermittent | *0.15* | | *9.7* | *1.32* | |
| | | Aerobic | *0.18* | | *8.5* | *1.56* | |
| USA | *indica* | Flooded | *0.70* (mean) | | - | - | G.J. Norton *et al*.(2012)(7) |
| | | Non flooded | *0.045* (mean) | | - | | |
| | *japonica* | Flooded | *0.50* (mean) | | - | | |
| | | Non flooded | *0.040* (mean) | | - | | |

| Country | *Subspecies* | way of irrigation water | Total As conc. in grain (mg/kg) | Inorganic As conc. in rice (mg/kg) | Yield (t/ha) | Cd conc. in grain (mg/kg) | Reference |
|---|---|---|---|---|---|---|---|
| Bangladesh | *indica* | Flooded in 11.6 mg/kg-As soil | *0.54* | | 8.9 | - | J. M. Duxbury *et al.* (2007)(8) |
| | | Flooded in 26.3 mg/kg-As soil | *0.53* | | 8.1 | | |
| | | Aerobic (on raised beds) in 11.6 mg/kg-As soil | *0.26* | | 7.8 | | |
| | | Aerobic (on raised beds) in 26.3 mg/kg-As soil | *0.28* | | 8.2 | | |
| Japan | *japonica* | (In the period of each 3 weeks before and after flowering) all ) flooded in all period | 0.24 | 0.19 | - | - | Unpublished data |
| | | Before heading flooded, after heading aerobic | 0.19 | 0.18 | - | - | |
| | | Before heading aerobic, after heading flooded | 0.19 | 0.17 | - | - | |
| | | aerobic in all period | 0.15 | 0.14 | - | - | |
| USA | | Flood | 0.236 a* | | 18.4 (kL/ha) | 0.019 c | Anders *et al.* (2013)(9) |
| | | AWD/60 | 0.177 b | | 17.2 | 0.042 b | |
| | | AWD/40-Flood | 0.164 bc | | 17.8 | 0.049 b | |
| | | AWD/40 | 0.138 c | | 16.6 | 0.058 ab | |
| | | Row/60 | 0.039 d | | 12.7 | 0.067 a | |
| | | Row/40 | 0.025 d | | 12.1 | 0.066 a | |

*The figures were estimated from bar graphs in the papers.*

* Means followed by the same letter are not significantly different (<0.05) according to the Duncan multiple range test

There was another study conducted in Italy on control of irrigation water. In this study, soil was saturated with water using sprinkler (hereinafter referred to as “saturated condition”). As a result, As concentrations were largely decreased in saturated condition (0.001-0.005 mg/kg) compared to the flooded condition ((0.095-0.23 mg/kg). This result was observed regardless of rice subspecies (*japonica* and *indica)*(10).

C) Selection of cultivars

Information and data of field experiments regarding selection of cultivars included in CX/CF 13/7/14 and those provided by USA are compiled in Table 2:3.

Table 2:3: Variations of As concentrations in rice cultivars

| Country | Cultivar | | Water management | As analyte | Husked/ Polished | Conc. in grain (mg/kg) | | | Ref. |
|---|---|---|---|---|---|---|---|---|---|
| | *Subspecies* | Number of cultivars tested | | (Total or Inorganic) | | Min | Median | Max | |
| USA (California) | *japonica* | 16 | | Total | Husked | 0.02 | 0.12 | 0.26 | Submitted Data from USA |
| | | 6 | | | Polished | 0.05 | 0.08 | 0.15 | |
| | | 16 | | Inorganic | Husked | 0.01 | 0.09 | 0.19 | |
| | | 6 | | | Polished | 0.01 | 0.06 | 0.11 | |
| USA (Arkansas) | *japonica* | 1 | | Total | Husked | 0.10 | 0.20 | 0.38 | |
| | | — | | | Polished | — | — | — | |
| | | 1 | | Inorganic | Husked | 0.09 | 0.14 | 0.23 | |
| | | — | | | Polished | — | — | — | |
| USA (Texas) | *japonica* | 1 | | Total | Husked | 0.20 | 0.55 | 1.03 | |
| | | 1 | | | Polished | 0.22 | 0.41 | 0.51 | |
| | | 1 | | Inorganic | Husked | 0.10 | 0.21 | 0.24 | |
| | | 1 | | | Polished | 0.08 | 0.08 | 0.16 | |
| Bangladesh | | 5 | 3-4 cm water from soil level was maintained throughout the growth period. | Total | Husked | 0.24 | 0.28 | 0.31 | ・M. Azizur Rahman *et al.* (2007)(11) |
| | | | | | Polished | 0.14 | 0.18 | 0.23 | |
| | | 5 | | Total | Husked | 0.31 | 0.51 | 0.53 | |
| | | | | | Polished | 0.28 | 0.33 | 0.42 | |
| | | 5 | | Total | Husked | 0.38 | 0.61 | 0.67 | |
| | | | | | Polished | 0.32 | 0.49 | 0.58 | |
| | | 5 | | Total | Husked | 0.47 | 0.59 | 0.75 | |
| | | | | | Polished | 0.43 | 0.54 | 0.65 | |
| Japan | *japonica* | 10* | Full irrigation was applied until grain harvesting after mid-season drainage. | Total | Husked | 0.11 | 0.14 | 0.17 | ・M. Kuramata *et al.* (2011)(12) |
| | | | | Inorganic | | 0.08 | 0.11 | 0.13 | |
| Japan | *japonica* | 10* | Full irrigation was applied until grain harvesting. | Total | Husked | 1.9 | 2.5 | 3.1 | |

| Country | Cultivar |  | Water management | As analyte (Total or Inorganic) | Husked/ Polished | Conc. in grain (mg/kg) |  |  | Ref. |
|---|---|---|---|---|---|---|---|---|---|
|  | *Subspecies* | Number of cultivars tested |  |  |  | Min | Median | Max |  |
|  |  |  |  | Inorganic |  | 0.14 | 0.20 | 0.24 |  |
| Faridpur (Bangladesh) |  | 72 | Continually flooded condition | Total | Husked | 0.16 | 0.39 | 0.74 | ・G. J.Norton *et al.* (2009) (13, 14) |
| Sonargaon (Bangladesh) |  | 76 | Alternative wet-dry cycles | Total | Husked | 0.07 | 0.17 | 0.28 |  |
| De Ganga (India) |  | 80 | Continually flooded condition | Total | Husked | 0.11 | 0.36 | 0.84 |  |
| Nonaghata (India) |  | 79 | Continually flooded condition | Total | Husked | 0.05 | 0.27 | 0.73 |  |
| Chenzhou (China) |  | 80 |  | Total | Husked | 0.27 | 0.41 | 0.75 |  |
| Qiyang (China) |  | 77 |  | Total | Husked | 0.37 | 0.57 | 0.85 |  |
| China |  | 6 | Flooded condition (a layer of water about 2-3 cm above the soil surface) | Inorganic | Husked | 0.15 | 0.22 | 0.35 | ・W. J. Liu *et al.* (2006) (15) |
|  |  |  |  | Total | Husked | 0.32 | 0.35 | 0.69 |  |
| USA | *japonica* *indica* | 3 | Saturated condition (maintaining soil moisture at or above the field capacity) | Total | Husked | *0.28*** | *0.40*** | *0.56*** | ・B. Hua *et al.* (2011) (16) |
| USA | *japonica* *indica* | 3 | Flooded condition from about the five-leaf stage to full maturity | Total | Husked | *0.46*** | *1.32*** | *1.48*** |  |
| USA | *japonica* *indica* | 3 | Saturated condition (maintaining soil moisture at or above the field capacity) | Total | Husked | *0.10*** | *0.16*** | *0.18*** |  |

| Country | Cultivar | | Water management | As analyte | Husked/ Polished | Conc. in grain (mg/kg) | | | Ref. |
|---|---|---|---|---|---|---|---|---|---|
| | *Subspecies* | Number of cultivars tested | | (Total or Inorganic) | | Min | Median | Max | |
| USA | *japonica*<br>*indica* | 3 | Flooded condition from about the five-leaf stage to full maturity | Total | Husked | *0.36*** | *0.44*** | *0.54*** | |
| Japan | *japonica*<br>*indica* | 58 | Flooded condition except mid-summer drainage in early July | Total | Husked | | | | ・M Kuramata *et al.* (2013)(17) |
| | | | | 2009 | | 0.08 | 0.19 | 0.33 | |
| | | | | 2008 | | 0.03 | 0.10 | 0.18 | |
| | | | | 2007 | | 0.08 | 0.18 | 0.30 | |
| | | | | Inorganic | Husked | | | | |
| | | | | 2009 | | 0.06 | 0.15 | 0.27 | |
| | | | | 2008 | | 0.01 | 0.05 | 0.16 | |
| | | | | 2007 | | 0.05 | 0.11 | 0.24 | |
| China | *japonica*<br>*indica* | 8 | | Total | Polished | 0.24 | 0.48 | 0.55 | ・X-L. Ren *et al*. (2006)(18) |
| USA | *japonica(8)*<br>*indica(13)* | 21 | Flooded condition until 1 week before harvest | Total | Polished | | | | ・T. R. Pillai *et al*. (2010)(19) |
| | | | | 2005 | | 0.27 | 0.48 | 1.83 | |
| | | | | 2004 | | 0.19 | 0.42 | 0.86 | |
| USA | *japonica(3)*<br>*indica(7)* | 10 | Flooded condition until 1 week before harvest | Total | Polished | | | | |
| | | | | 2007 | | 0.27 | 0.38 | 0.63 | |
| | | | | 2004 | | 0.27 | 0.46 | 0.60 | |
| | | | | Inorganic | | | | | |
| | | | | 2007 | | 0.09 | 0.13 | 0.15 | |
| | | | | 2004 | | 0.09 | 0.12 | 0.15 | |
| Bangladesh | *japonica*<br>*indica* | 312 | Flooded condition until when a majority of the cultivars had flowered and then the field was dried until harvest. | | Polished | 0.19 | 0.44 | 0.90 | ・G. J. Norton *et al*. (2012) (7) |

| Country | Cultivar | | Water management | As analyte | Husked/ Polished | Conc. in grain (mg/kg) | | | Ref. |
|---|---|---|---|---|---|---|---|---|---|
| | *Subspecies* | Number of cultivars tested | | (Total or Inorganic) | | Min | Median | Max | |
| China | *japonica*<br>*indica* | 295 | Flooded condition until when a majority of the cultivars had flowered and then the field was dried until harvest. | | Husked | 0.36 | 0.66 | 1.27 | |
| Arkansas(USA) | *japonica*<br>*indica* | 352 | A flood was applied at five-leaf stage and drained 15-20 days after all the cultivars had flowered. Then the field was dried until harvest. | 2007 | Husked | 0.03 | 0.21 | 1.04 | |
| | | 346 | | 2006 | | 0.10 | 0.36 | 0.99 | |
| Texas(USA) | *japonica*<br>*indica* | 377 | Flush irrigation until plants reached an average 18cm height, and then flooded condition. | | Husked | 0.17 | 0.62 | 1.68 | |
| Texas(USA) | *japonica*<br>*indica* | 374 | Flush irrigation was continued to keep the root damp but not saturated. | | Husked | 0.01 | 0.04 | 0.13 | |

* nine non-glutinous cultivars and one glutinous cultivar

** The figures were picked up from bar graphs in Figure 1 in the paper.

CONSIDERATION OF MEASURES ON PROCESSING AND COOKING

1. Processing (milling)

(1) Comparison of mean As concentrations in husked and polished rice

Among the data provided by Australia, China, Indonesia, Japan, Kenya, Singapore, Thailand and the USA in response to the data call, total 8066 data points that samples with sub-species (*indica* or *japonica*) and type of rice (husked or polished) identified are used as basis for the calculation. Arsenic concentrations in husked rice and polished rice were compared using the Mann-Whitney U test for each combination of rice subspecies (*indica*, *japonica*)/As types (tAs, iAs). In all combinations of rice subspecies/As types, the results showed the statistical differences between husked rice and polished rice at the 5% level of significance.

Table 3:1 Comparison of mean As concentration of husked rice and polished rice

| | Husked rice | | | | Polished rice | | | | Conc. Ratio (mean of As conc. in polished / in husked) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total As | | Inorganic As | | Total As | | Inorganic As | | | |
| | n | Mean Conc. (mg/kg) | n | Mean Conc. (mg/kg) | n | Mean Conc. (mg/kg) | n | Mean Conc. (mg/kg) | Total As (%) | Inorganic As (%) |
| *indica* | 716 | 0.23 | 655 | 0.17 | 1127 | 0.14 | 912 | 0.09 | 61 | 52 |
| *japonica* | 1477 | 0.20 | 1470 | 0.17 | 889 | 0.13 | 820 | 0.11 | 65 | 65 |

(2) Reduction of As concentration by milling

There are three studies conducted by China and Japan, showing the percentage of As concentration reduced by milling. In these studies, the samples from the same lots were used and As concentrations were determined for both husked and polished rice. As mentioned in the latter section, since concentration of As in rice differ depending on the DP (degree of polishing) %*, we only used data with 90 of DP% for Japanese data in this section. (When we say polished rice in Japan, DP% is usually 90.)

* DP% is a percentage of grain remaining after milling. For example, if the DP% is 90, 90% of the grain remains after milling, and 10% of the outer layers are polished off.

Table 3:2: Reduction of As concentration by milling

| Country | *Subspeices* | Husked rice | | Polished rice | | Conc. Ratio (polished / husked) | | Ref. |
|---|---|---|---|---|---|---|---|---|
| | | Total As (mg/kg) | Inorganic As (mg/kg) | Total As (mg/kg) | Inorganic As (mg/kg) | Total As (%) | Inorganic As (%) | |
| China | *japonica* | 0.083-0.739<br>0.255(mean) | 0.071-0.567<br>0.209(mean) | 0.033-0.437<br>0.143(mean) | 0.028-0.217<br>0.108(mean) | 37-98<br>64(mean) | 36-97<br>52(mean) | Xie K. *et al*. (2013)(20) |
| Japan | *japonica* | 0.487 | 0.431 | 0.296 | 0.221 | 61 | 51 | Unpublished data |
| | | 0.223 | 0.208 | 0.147 | 0.132 | 66 | 63 | |
| | | 0.040 | 0.044 | 0.025 | 0.031 | 64 | 71 | |
| Japan | *japonica* | 0.173 | 0.156 | 0.107 | 0.097 | 62 | 62 | Narukawa *et al*. (2011)(21) |

(3) Relation between DP % and reduction of As concentration

One study conducted in Japan showed the relation between DP% and As concentration in rice. Total and inorganic As concentration of three samples from the same lots were determined for husked rice, 95DP% polished rice, 90DP% polished rice, and for one sample 87DP% polished rice.

Table 3:3 Relation between DP% and reduction of As concentration

| | Husked rice | Polished rice (Conc. ratio of polished/husked) | | |
|---|---|---|---|---|
| DP% | 100 | 95 | 90 | 87* |
| Total As (mg/kg) | 0.487 | 0.411 (84%) | 0.296 (61%) | |
| | 0.223 | 0.179 (80%) | 0.147 (66%) | 0.125 (55%) |
| | 0.040 | 0.033 (84%) | 0.025 (64%) | |
| Inorganic As (mg/kg) | 0.431 | 0.325 (75%) | 0.221 (51%) | |
| | 0.208 | 0.156 (75%) | 0.132 (63%) | 0.119 (58%) |
| | 0.044 | 0.039 (88%) | 0.031 (71%) | |

* Rice with bran completely removed is called “rinse-free rice” in Japan. The rice sample with 87DP% is an example of “rinse-free rice.” (Usually husked rice is polished to approximately 90DP% to be called as “polished rice.”)

2. Preparation (washing) and Cooking

(1) Reduction of As concentration by rinse

Three studies showing change in As concentration by washing were provided by India, Japan and UK. All three studies used non-contaminated water for washing rice and As concentration was determined before and after the rinse.

Table 3:4 Reduction of As concentration by rinse used non-contaminated water

| Country | *Subspecies* | Uncooked rice | | | Rinsed rice | | | | Conc. ratio (rinsed/uncooked) | | Ref. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Type | Total As (mg/kg) | Inorganic As (mg/kg) | Number of times | Water conc. (mg/L) | Total As (mg/kg) | Inorganic As (mg/kg) | Total As (%) | Inorganic As (%) | |
| Japan | *japonica* | Polished | 0.298<br>0.147 | 0.231<br>0.138 | 3 | (<0.01)<br>(DDW) | 0.242<br>0.123 | 0.163<br>0.114 | 81<br>84 | 71<br>83 | Unpublished data |
| UK | *indica* (basmati) | Polished | 0.162 | 0.093 | 2 | DDW* | 0.141 | 0.086 | 87 | 92 | Raab *et al.*(2008)(22) |
| | | Husked | 0.131 | 0.089 | | | 0.111 | 0.080 | 85 | 90 | |
| | *indica* (long grain) | Polished | 0.229 | 0.138 | | | 0.222 | 0.131 | 97 | 95 | |
| | | Husked | 0.314 | 0.183 | | | 0.311 | 0.157 | 99 | 86 | |
| India | *indica* | Polished | 0.204-0.540 | | 5-6 | <0.003 | | | 77 | | M.K.Sengupta *et al.* (2006)(23) |

*DDW means "double distilled deionized water."

(2) Change of As concentration in the cooking process

Three types of studies were conducted in this area. One type is the study using non-contaminated water and determine tAs and iAs concentration before and after the cooking (Table 3:5 by India and UK). Another type is using As-contaminated water and determine inorganic As concentration before and after the cooking (Table 3:6 by Spain). And at last, determine the total and inorganic As concentration for rice cooked with As-contaminated water and non-contaminated water (Table 3:7 by the USA). In USA, a study related to change of As concentration during processing and cooking in addition to these three studies is currently underway.

Table 3:5 Change of total As concentration in rinse and cooking process using non-contaminated water (Study conducted by India and UK)

| Country | *subspecies* | Analyte | Uncooked rice | | Rinsed rice | | Cooked rice | | | Conc. ratio As (%) | | Ref. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Type | As (mg/kg) | Number of times | Water conc. (mg/L) | Rice/ Water ratio | Water conc. (mg/L) | As (mg/kg) | rinsed/ uncooked | cooked/ uncooked | |
| India | *indica* | Total | Polished | 0.204-0.540 | 5-6 | <0.003 | 1:5 - 1:6 discard water | <0.003 | | 77 | 42-45 | M.K.Sengupta *et al.* (2006)(23) |
| | | | Polished | 0.204-0.540 | 5-6 | <0.003 | 1:1.5 – 1:2 | <0.003 | | | 70-74 | |
| | | | Polished | 0.204-0.540 | 0 | <0.003 | 1:1.5 – 1:2 | <0.003 | | | 99-101 | |
| *UK* | *indica* (basmati) | Total | Polished | 0.162 | 2 | DDW* | 1:2.5 | DDW* | 0.141 | 87 | 87 | A Raab *et al.*(2008)(22) |
| | | | | | | | 1:6 discard water | | 0.103 | 87 | 64 | |
| | | Inorganic | | 0.093 | | | 1:2.5 | | 0.090 | 92 | 92 | |
| | | | | | | | 1:6 discard water | | 0.056 | 92 | 60 | |
| | | Total | Husked | 0.131 | | | 1:2.5 | | 0.119 | 85 | 85 | |
| | | | | | | | 1:6 discard water | | 0.072 | 85 | 55 | |
| | | Inorganic | | 0.089 | | | 1:2.5 | | 0.082 | 90 | 90 | |
| | | | | | | | 1:6 discard water | | 0.048 | 90 | 54 | |
| | *indica* (long grain) | Total | Polished | 0.229 | 2 | DDW* | 1:2.5 | DDW* | 0.238 | 97 | 97 | |
| | | | | | | | 1:6 discard water | | 0.165 | 97 | 72 | |
| | | Inorganic | | 0.138 | | | 1:2.5 | | 0.144 | 95 | 95 | |
| | | | | | | | 1:6 discard water | | 0.070 | 95 | 51 | |
| | | Total | Husked | 0.314 | | | 1:2.5 | | 0.324 | 99 | 99 | |
| | | | | | | | 1:6 discard water | | 0.219 | 99 | 70 | |
| | | Inorganic | | 0.183 | | | 1:2.5 | | 0.157 | 86 | 86 | |
| | | | | | | | 1:6 discard water | | 0.149 | 86 | 56 | |

Table 3:6 Change of iAs concentration in cooking process by using As-contaminated water (Study conducted by Spain)

| *Subspecies* | Uncooked rice | | Cooked rice | | | Conc. ratio (cooked/ uncooked) | Ref. |
|---|---|---|---|---|---|---|---|
| | Type | Inorganic As (mg/kg) | Rice/ Water ratio | Water conc. (mg/L) | Inorganic As (mg/kg) | Inorganic As (%) | |
| *Unknown* (long white) | Polished | 0.15 | 1:4 | 0.1<br>0.3<br>0.6 | *0.40*<br>*1.30*<br>*2.85* | 270<br>870<br>1900 | Torres *et al.* (2008)(24) |
| *Unknown* (short brown) | Husked | 0.20 | 1:4 | 0.2<br>0.4<br>0.6 | *0.80*<br>*1.45*<br>*2.30* | 400<br>730<br>1200 | |
| *Unknown* (long brown) | Husked | 0.15 | 1:4 | 0.2<br>0.4<br>0.6 | *0.85*<br>*1.70*<br>*2.10* | 570<br>1100<br>1400 | |
| *Unknown* (white Thai) | Polished | 0.10 | 1:4 | 0.2<br>0.4<br>0.7 | *0.70*<br>*1.50*<br>*3.25* | 700<br>1500<br>3300 | |

Table 3:7 Comparison of tAs concentration of cooked rice using As-contaminated water and non-contaminated water (Study conducted by the USA)

| *Subspecies* | Type | Rice/ Water ratio | Water conc. (mg/L) | Rice conc. (mg/kg) | | Ref. |
|---|---|---|---|---|---|---|
| | | | | Total As | Inorganic As | |
| *Unknown (short grain )* | Husked | from1:1 to 1:4 | 0<br>21.9 (As(V)) | 0.119<br>0.178 | 0.108<br>0.166 | Ackerman *et al.* (2005)(25) |
| *Unknown (short grain )* | Polished | from1:1 to 1:4 | 0<br>21.9 (As(V)) | 0.099<br>0.162 | 0.084<br>0.128 | |
| *Unknown (long grain )* | Polished | from 1:1 to 1:4 | 0<br>21.9 (As(V)) | 0.236<br>0.310 | 0.083<br>0.143 | |

**APPENDIX V**

**Reference**


1. Ishikawa, S., Ishimaru, Y., Igura, M., Kuramata, M., Abe, T.*, et al.*, *Ion-beam irradiation, gene identification, and marker-assisted breeding in the development of low-cadmium rice.* Proceedings of the National Academy of Sciences, 2012. **109**(47): p. 19166-19171.

2. Ueno, D., Yamaji, N., Kono, I., Huang, C.F., Ando, T.*, et al.*, *Gene limiting cadmium accumulation in rice.* Proceedings of the National Academy of Sciences, 2010. **107**(38): p. 16500-16505.

3. Bae, M., Watanabe, C., Inaoka, T., Sekiyama, M., Sudo, N.*, et al.*, *Arsenic in cooked rice in Bangladesh.* The Lancet, 2002. **360**(9348): p. 1839-1840.

4. Xie, Z.M. and Huang, C.Y., *Control of arsenic toxicity in rice plants grown on an arsenic-polluted paddy soil.* Communications in Soil Science and Plant Analysis, 1998. **29**(15-16): p. 2471-2477.

5. Sarkar, S., Basu, B., Kundu, C.K. and Patra, P.K., *Deficit irrigation: An option to mitigate arsenic load of rice grain in West Bengal, India.* Agriculture, Ecosystems & Environment, 2012. **146**(1): p. 147-152.

6. Hu, P., Li, Z., Yuan, C., Ouyang, Y., Zhou, L.*, et al.*, *Effect of water management on cadmium and arsenic accumulation by rice (Oryza sativa L.) with different metal accumulation capacities.* Journal of Soils and Sediments, 2013. **13**(5): p. 916-924.

7. Norton, G.J., Pinson, S.R.M., Alexander, J., Mckay, S., Hansen, H.*, et al.*, *Variation in grain arsenic assessed in a diverse panel of rice (Oryza sativa) grown in multiple sites.* New Phytologist, 2012. **193**(3): p. 650-664.

8. Duxbury, J. and Panaullah, G., *Remediation of Arsenic for agriculture sustainability, food security and health in Bangladesh (Working paper).* Cornell University and Bangladesh joint publication, FAOWater, FAO, Rome, 2007.

9. Anders *et al.*, *Effect of Water Management on Brown Rice Yield, and Total As and Cd Concentrations*, in *Proc. International Plant Nutrition Colloquium,* 2013: Istanbul, Turkey.

10. Spanu, A., Daga, L., Orlandoni, A.M. and Sanna, G., *The Role of Irrigation Techniques in Arsenic Bioaccumulation in Rice (Oryza sativa L.).* Environmental Science & Technology, 2012. **46**(15): p. 8333-8340.

11. Rahman, M.A., Hasegawa, H., Rahman, M.M., Islam, M.N., Miah, M.a.M.*, et al.*, *Arsenic accumulation in rice (Oryza sativa L.) varieties of Bangladesh: A glass house study.* Water Air and Soil Pollution, 2007. **185**(1-4): p. 53-61.

12. Kuramata, M., Abe, T., Matsumoto, S. and Ishikawa, S., *Arsenic accumulation and speciation in Japanese paddy rice cultivars.* Soil Science and Plant Nutrition, 2011. **57**(2): p. 248-258.

13. Norton, G.J., Duan, G., Dasgupta, T., Islam, M.R., Lei, M.*, et al.*, *Environmental and Genetic Control of Arsenic Accumulation and Speciation in Rice Grain: Comparing a Range of Common Cultivars Grown in Contaminated Sites Across Bangladesh, China, and India.* Environmental Science & Technology, 2009. **43**(21): p. 8381-8386.

14. Norton, G.J., Islam, M.R., Deacon, C.M., Zhao, F.-J., Stroud, J.L.*, et al.*, *Identification of Low Inorganic and Total Grain Arsenic Rice Cultivars from Bangladesh.* Environmental Science & Technology, 2009. **43**(15): p. 6070-6075.

15. Liu, W.J., Zhu, Y.G., Hu, Y., Williams, P.N., Gault, A.G.*, et al.*, *Arsenic sequestration in iron plaque, its accumulation and speciation in mature rice plants (Oryza sativa L.).* Environmental Science & Technology, 2006. **40**(18): p. 5730-5736.

16. Hua, B., Yan, W.G., Wang, J.M., Deng, B.L. and Yang, J., *Arsenic Accumulation in Rice Grains: Effects of Cultivars and Water Management Practices.* Environmental Engineering Science, 2011. **28**(8): p. 591-596.

17. Kuramata, M., Abe, T., Kawasaki, A., Ebana, K., Shibaya, T.*, et al.*, *Genetic diversity of arsenic accumulation in rice and QTL analysis of methylated arsenic in rice grains.* Rice, 2013. **6**(1): p. 3.

18. Ren, X.L., Liu, Q.L., Wu, D.X. and Shu, Q.Y., *Variations in concentration and distribution of health-related elements affected by environmental and genotypic differences in rice grains.* Rice Sci, 2006. **13**(170): p. l78.

19. Pillai, T.R., Yan, W., Agrama, H.A., James, W.D., Ibrahim, A.M.H.*, et al.*, *Total grain-arsenic and arsenic-species concentrations in diverse rice cultivars under flooded conditions.* Crop Science, 2010. **50**(5): p. 2065-2075.

20. Xie, K., Bin, Y., Feng, H., Xiao-Hong, S., Xiao-Wei, L.*, et al.*, *Arsenic and arsenic speciation and exposure assessment for rice from China's major producing areas by HPLC-ICP-MS.* Environmental Science & Technology, 2013. **in press**.

21. Narukawa, T., Hioki, A. and Chiba, K., *Speciation and Monitoring Test for Inorganic Arsenic in White Rice Flour.* Journal of Agricultural and Food Chemistry, 2011. **60**(4): p. 1122-1127.

22. Raab, A., Baskaran, C., Feldmann, J. and Meharg, A.A., *Cooking rice in a high water to rice ratio reduces inorganic arsenic content.* Journal of Environmental Monitoring, 2009. **11**(1): p. 41-44.

23. Sengupta, M.K., Hossain, M.A., Mukherjee, A., Ahamed, S., Das, B., *et al.*, *Arsenic burden of cooked rice: Traditional and modern methods.* Food and Chemical Toxicology, 2006. **44**(11): p. 1823-1829.

24. Torres-Escribano, S., Leal, M., Vélez, D. and Montoro, R., *Total and Inorganic Arsenic Concentrations in Rice Sold in Spain, Effect of Cooking, and Risk Assessments.* Environmental Science & Technology, 2008. **42**(10): p. 3867-3872.

25. Ackerman, A.H., Creed, P.A., Parks, A.N., Fricke, M.W., Schwegel, C.A., *et al.*, *Comparison of a Chemical and Enzymatic Extraction of Arsenic from Rice and an Assessment of the Arsenic Absorption from Contaminated Water by Cooked Rice.* Environmental Science & Technology, 2005. **39**(14): p. 5241-5246.

**APPENDIX VI**

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