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COPPER: EUROPEAN CONSUMERS EXPOSURE

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ABSTRACT

Copper (Cu) is an ubiquitous trace metallic element and an essential micronutrient for all living organisms. Copper is widely used as fungicide or bactericidal product but also as animal feed additive or fertilizers. In the framework of its activities, Anses (French Agency for Food, Environmental and Occupational Health & Safety) assessed the global exposure to copper of European consumers. According to the results, the Acceptable Daily Intake (ADI) set for copper is not exceeded and no chronic risk has been identified. Phytosanitary products contribute significantly in the consumer exposure. Nevertheless the margin of safety remains low and a significant level of uncertainties was noted. Further data would be necessary for both food and water at the EU level.

Keywords: chronic risk, copper, consumer, exposure, phytosanitary.

RÉSUMÉ

CUIVRE : EXPOSITION DES CONSOMMATEURS EUROPEENS

Le cuivre (Cu) est un élément trace métallique ubiquitaire et un oligo-élément essentiel pour tous les organismes vivants. Il est également largement utilisé en agriculture en tant que fongicide/bactéricide mais aussi en tant que complément alimentaire pour les animaux d'élevage ou comme engrais. Dans le cadre de ses activités, l'Anses (Agence nationale de Sécurité Sanitaire de l'alimentation, de l'environnement et du travail) a estimé l'exposition globale des consommateurs européens au cuivre. Les résultats montrent que compte tenu de la Dose Journalière Admissible (DJA) du cuivre, aucun risque chronique n'a été identifié, les produits phytopharmaceutiques représentant une part significative de cette exposition. La marge de sécurité est cepandant faible et le niveau d'incertitudes élevé. Des données supplémentaires sur les denrées alimentaires et l'eau seraient nécéssaires au niveau Européen.

Mots-clés : cuivre, consommateurs, exposition, phytosanitaire, risque chronique.

INTRODUCTION

Copper is released from both natural and man-made sources (including fertilizer, phytosanitary, biocides, feed additive, veterinary drugs, etc.). It is ubiquitous in the environment which leads to an unavoidable daily exposure of the population.

As regards phytosanitary uses, copper is a fungicide applied as a foliar spray for the control of various diseases in a range of edible crops since the 19th century. The active substance is delivered from the five forms of copper compounds, copper hydroxide, copper oxychloride, Bordeaux mixture, tribasic copper sulphate and copper (I) oxide.

Copper was included on Annex I of Directive 91/414/EEC by Directive 2009/37/EC and was approved under Regulation (EC) 1107/2009 by Commission Regulation (EU) No 540/2011 (entry No 277) that replaced Directive 2009/37/EC as a result of the evaluation carried out by France as Rapporteur Member state (RMS) for copper. France also conducted the review of the existing Maximum Residue Levels (MRLs).

In the framework of these activities, the consumer exposure *via* food was calculated using the regulatory risk assessment model PRIMo (Pesticide Residue Intake Model) as well as in force copper MRLs (Maximum Residue Levels) as input values which results in an exceedance (>400%) of the ADI (Acceptable Daily Intake). This scenario is a worst case scenario since it is assumed that all consumed products are contaminated at the MRL level and all products are consumed raw without taking the decline of residue level by processing into account. This worst case scenario is also called the Theoretical Maximum Daily Intake (TMDI) calculation.

As the TMDI was found to exceed the ADI, refinement was performed using median residue values, processing data for all registered uses (IEDI - International Estimated Daily Intake scenario). However, in this particular case, as copper is ubiquitous, all commodities had to be taken into account even if there was no use is registered.

In this context, chronic exposure to copper linked to food and drinking water consumption was estimated.

MATÉRIAL ET METHOD

TOXICOLOGICAL DATA

To estimate the chronic risk of European consumers linked to ingestion of copper, an ADI is taken into account.

For copper, an ADI of 0.15 mg/kg bw/d was set at the EU level. It is based on the values established by the WHO (World Health Organization) for copper intake based on human data in children (adults: 0.2 mg Cu/kg bw/d and children: 0.15 mg/kg bw/d), and supported by animal data (1-year dog study) with a NOAEL (No Observed Adverse Effect Level) of 15 mg/kg bw/d. For the human study, no safety factor was attributed to set up Toxicological Reference Value (VTR), and for the dog study a standard safety factor of 100 was applied (EFSA, 2008; EC, 2014).

CONSUMPTION DATA AND EXPOSURE MODEL

In the framework of regulatory assessment of phytosanitary products, PRIMo rev.2 is recommended for assessing acute and chronic exposure for adults, children and general populations in order to harmonize all European evaluations. This model was created by EFSA (European Food Safety Authority) and includes all available EU MS diets.

In total 26 diets (4 international diets and 22 national diets) including 319 raw food commodities were compiled in the database to be used for the chronic risk assessment. The 4 international diets correspond to the WHO cluster diets which include significant contribution from European countries. The WHO diets are based on a cluster analysis approach, using major food groups and data from 183 countries worldwide (WHO, 2003, 2006). The national diets are based on the national food consumption data, collected by EFSA. Out of the 25 EU MS, data concerning the long-term consumption were available from 13 MS. Considering that some MS have submitted data for more than one sub-population (e.g. children and adults, elderlies, vegetarians) a total of 22 national diets have been compiled.

CONTAMINATION DATA

Endogenous copper from literature review

As copper is a natural compound, consumers are exposed to copper *via* all food commodities listed in PRIMo. Literature data were also considered to estimate the endogenous levels of copper (ANSES/Ciqual, 2013) (Health Canada, 2010) (Saxholt *et al*, 2008) (SCAN, 2003) (SOUCI *et al*, 2000) (TACO, 2011) (WHO, 2012).

Data from treated plant with phytosanitary products

In the framework of the review of copper MRLs, residue trials from treated crops are available. Only authorized uses as plant protection products were considered.

EXPOSURE VIA FOOD

The estimation of the exposure linked to the use of phytosanitary products was conducted in two steps.

During the 1st step, the endogenous chronic exposure to copper for the European consumer was estimated.

When data were sufficient, median copper concentrations were taken into account for both animal and plant commodities. However, in absence of data for some commodities, some extrapolations were considered according to the group of commodities defined in annex 1 of Reg. (EC) 1107/2009.

At the 2nd step, the chronic exposure for the European consumer also linked to all uses of copper as phytosanitary product was estimated.

For commodities listed in Table I, the Supervised Trials Median Residues (STMR) were used as input values in the model when sufficient data were available to define a MRL.

Table I : Plant commodities for which sufficient data were available (Denrées végétales pour lesquelles suffisamment de données étaient disponibles)

Groups	Commodities (according to Reg. (EU) No 396/2005)
Arboriculture	Citrus fruits, closed tree nuts, pome fruits, stone fruits, kiwis, table olives and olives for oil production and jambolan
Berries	Table grapes, wine grapes, strawberries, raspberries, blueberries, cranberries, gooseberries, mulberries, azarole and elderberries
Root and tuber vegetables	Potatoes, tropical root and tuber vegetables, carrots, swedes and turnips
Bulb vegetables	Garlic, onions and shallots
Fruiting vegetables	Tomatoes, peppers, eggplants, cucurbits with edible peel and cucurbits with inedible peel
Brassica vegetables	Flowering brassica
Leafy vegetables	Lettuces and other, spinaches and similar and herbs
Legume vegetables	Beans with pods, peas with pods and peas without pods
Stem vegetables	Globe artichokes and leeks
Others	Hops

EXPOSURE VIA WATER

EFSA realized a Comprehensive Food Consumption Database, which can be a source of information on food consumption across the European Union (EFSA, 2011). It has been built from existing national information on food consumption at a detailed level.

This database clearly shows that the average consumption of “drinking water (water without any additives except carbon dioxide; includes water ice for consumption)” is quite different from one EU country to the other and from one group of consumer to the other.

For the evaluation, for each population’s category, as a worst case situation, the maximum water consumption was taken into account (Table II).

Table II: EFSA's concise European Food Consumption database for drinking water (base de données exhaustive sur la consommation alimentaire européenne pour l'eau de boisson).

Population	Range of mean consumption of drinking water
Adults (18 to 64 years old)	1.5 g/kg bw (Latvia, EFSA test) to 18 g/kg bw (Czech Republic, SISP04)
Adolescents (10 to 17 years old)	2.1 g/kg bw (Latvia, EFSA test) to 18.6 g/kg bw (Czech Republic, SISP04)
"other" children (3 to 9 years old)	2.8 g/kg bw (Latvia, EFSA_TEST) to 24.8 g/kg bw (Czech Republic, SISP04)
Toddlers (12 to 35 months)	11.4 g/kg bw (Belgium, FPDS_1) to 48.8 g/kg bw (Finland, DIPP)
Infants (up to 11 months)	49 g/kg bw (Bulgaria, Nutrichild) and 52.1 g/kg bw (Italy, INRAN_SCAI_2005_06)

Regulatory level scenario

The Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption set a maximum level of 2 mg/L of copper in water (*i.e.* 0.002 mg Cu/g water).
In this scenario, all the European populations were supposed to drink water which contains copper at the EU limit of 2 mg per litre.

Refined scenario

Data from SISE-Eaux database from French Ministry of Health were considered. Results of analysis of copper in tap water measured over a period from 1 January 2009 to 31 December 2013 (*i.e.* 5 years) were considered. This data set includes 85,892 measurements of copper content in tap water sampled after sufficient flushing. In this scenario, median level of 0.028 mg Cu/L was considered.

Drinking water exposure calculation

Depending on the level of copper in drinking water taken into account, the worst case situations concerning chronic exposure to copper linked to water consumption were estimated as follow:

$$Expo\ (Cu)_{Water} = Cons_{Water} \times [Cu]_{Water} (mg/L) \frac{100}{ADI\ (mg/kg\ bw/d)}$$

With

- Expo $(Cu)_{water}$: Exposure to copper linked to drinking water consumption (%ADI);
- $Cons_{Water}$: Drinking water consumption (g/kg bw).

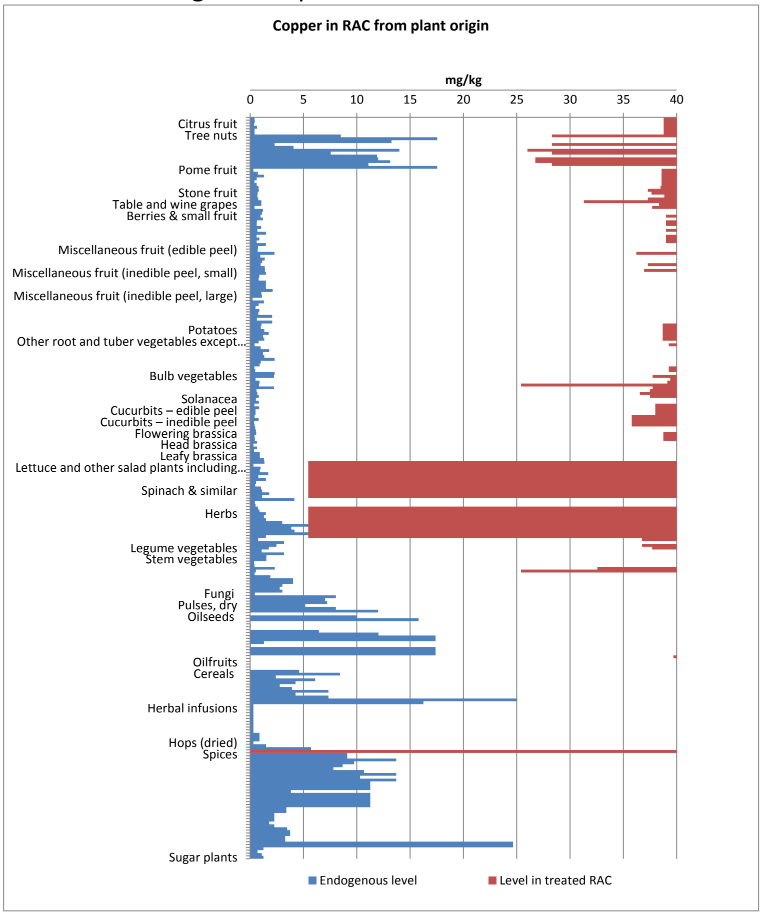
RESULTS

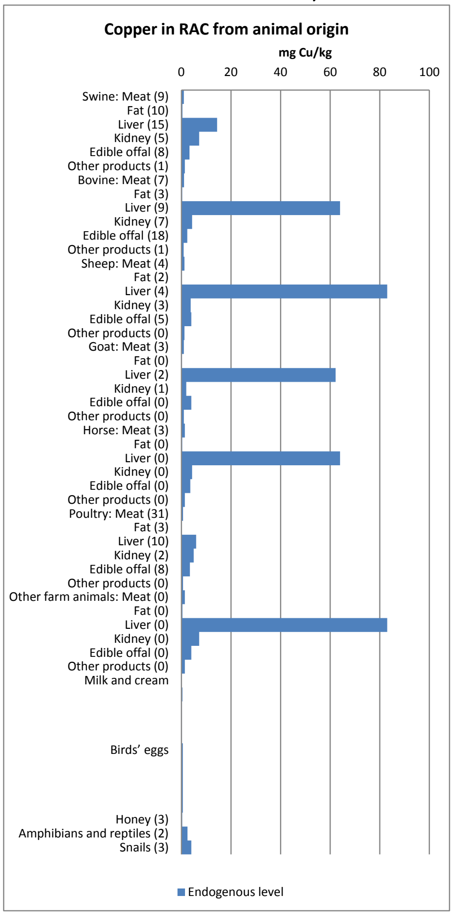
LEVELS OF COPPER CONTAMINATION IN FOODS

The residue levels of copper (endogenous and in treated Raw Agricultural Commodities (RAC)) in commodities of plant and animal origins are showed in Figure 1.
In commodities of plant origin, 80% of the endogenous residue levels are less than 5 mg/kg.
The highest endogenous copper residue levels (25 mg/kg) were measured in tea and some spices (2-25 mg/kg). The endogenous copper levels are higher than 10 mg/kg in coffe beans, some oilseeds and tree nuts. In fruit crops, only tree nuts show a such a high endogenous copper level (2.3-17.5 mg/kg). The endogenous copper levels are higher than 5 mg/kg in cereals, pulses and some herbs.
In commodities of animal origin, the highest residue levels of copper are measured in liver (6-83 mg/kg) then in kidney (2-7 mg/kg) and edible offals (2.4-4 mg/kg). In muscle, the level of copper is always below 1.5 mg/kg, in eggs it is about 0.6 mg/kg and in fat and milk copper level is always below 0.5 mg/kg.
When phytosanitary copper products are sprayed on crops according to the authorised GAP, the median residue level of copper can reach 350 mg/kg in hop then 35 mg/kg in lettuce. The increase of copper level is also significant for leek (and spring onion) as the median residue level was calculated at 14.6 mg/kg.

Conversely, after treatment on closed nut tree (except for chestnut), there is no significant increase of the level of copper.
After treatment, the residue level is between 5 and 10 mg/kg for grape and globe artichoke.
For all other treated crops, the level of copper is below 5 mg/kg even if an increase of copper has been measured between endogenous level and the one after treatment.

Figure 1: Endogenous Levels of Copper in foods and levels after copper treatment (Niveaux de cuivre endogène et après traitement dans les aliments destinés à l'alimentation humaine)





(in brackets, the number of data available for the calculation of the median endogenous level)

EXPOSURE

The calculated exposures were compared with the toxicological reference values derived for copper; detailed results of the calculation are presented in the Table below.

Exposure to copper *via* drinking water

Results, expressed as percentage of ADI (0.15 mg/kg bw/d) are summarised in Table III.
In the regulatory scenario, chronic exposure *via* water consumption is in the range of 24-70% ADI: drinking water would mainly contribute to copper exposure. Nevertheless, as for the assessment of dietary exposure, it seems more relevant to evaluate the exposure *via* drinking water by taking into account a more realistic scenario concerning the copper concentration in drinking water.
The refined scenario leads to an exposure in the range of 0.34-0.97% ADI; which can be considered as negligeable (less than 1%).

Table III: Worst case situations concerning chronic exposure to copper linked to drinking water consumption for each class of age of the European population (Situations pire cas concernant l'exposition chronique au cuivre *via* l'eau de boisson pour chaque classe d'âge de la population européenne)

Population	**Age**	**Source (higher mean consumption - all subjects)**	**Average "drinking water consumption" (g/kg bw)**	**Percentage of ADI (high level: 2 mg Cu/L)**	**Percentage of ADI (median level in France: 0.028mg Cu/L)**
Adults	18 to 64 years	Czech Republic, SISP04	18	24.0%	0.34%
Adolescents	10 to 17 years	Czech Republic, SISP04	18.6	24.8%	0.35%
Other children	3 to 9 years	Czech Republic, SISP04	24.8	33.1%	0.46%
Toddlers	12-35 months	Finland, DIPP	48.8	65.1%	0.91%
Infants	Up to 11 months	Italy, INRAN_SCAI_2005_06	52.1	69.5%	0.97%

Exposure to endogenous copper *via* food

Considering only the endogenous copper content of foods and using PRIMo, the chronic exposure to copper was significant as shown in the report Table IV. The maximum exposure to copper *via* endogenous reaches then 56.4% ADI for "IE adult" population.
One can notice that the main contributors to endogenous exposure to copper are cereals (highest exposure 24% ADI), sugar beet (19.1% ADI) and sheep liver (12.5% ADI).

Table IV : Chronic consumer exposure linked to endogenous copper content of foods (Exposition chronique au cuivre du consommateur liée à la teneur endogène des aliments)

Highest calculated TMDI values in % of ADI	**MS Diet**	**Highest contributor to MS diet (in % of ADI)**	**Commodity/ group of commodities**	**2nd contributor to MS diet (in % of ADI)**	**Commodity/ group of commodities**	**3rd contributor to MS diet (in % of ADI)**	**Commodity/ group of commodities**
56.4	IE adult	12.5	Sheep: Liver	6.5	Wheat	3.8	Barley
55.2	WHO Cluster diet B	24.2	Wheat	4.0	Maize	3.1	Bovine: Liver
43.5	UK Toddler	19.1	Sugar beet (root)	11.1	Wheat	4.1	Beans
39.3	DK child	15.6	Wheat	11.5	Rye	5.4	Bovine: Liver
38.4	NL child	13.5	Wheat	4.1	Potatoes	3.2	Bovine: Liver
33.8	WHO cluster diet D	18.5	Wheat	2.9	Potatoes	1.1	Rye
33.1	UK Infant	8.4	Sugar beet (root)	7.4	Wheat	3.9	Bovine: Liver

Exposure to endogenous copper *via* food and drinking water

If considering only endogenous copper and reguloratory scenario for water (2 mg/L) the most exposed populations are reported in the Table V. Then it appears that exposure to copper could be already close or higher than ADI.

Table V : Chronic consumer exposure linked to endogenous copper content in foods and drinking water ([Cu] = 2 mg/L) (Exposition chronique au cuivre du consommateur liée à la teneur endogène des aliments et l'eau de boisson ([Cu] = 2 mg/L))

MS Diet (PRIMo)	**Age (PRIMo)**	**Calculated exposure to endogenous Copper in % ADI *via***		
		Drinking water (with [Cu] water = 2 ppm)	**Foods endogenous (Refined PRIMo)**	**Total**
UK Toddler	18 months - 4 years	65,1	43,5	108,6
NL child	1-6	65,1	38,4	103,5
UK Infant	6-12 months	69,5	33,1	102,6
DE child	2-below 5	65,1	31,4	96,5
IE adult	18-64	24,0	56,4	80,4
WHO Cluster diet B	na	24,0	55,2	79,2

A refined scenario would lead to the following exposures detailed in Table VI:

Table VI : Chronic consumer exposure linked to endogenous copper and water ($[Cu]_{median}$ in France = 0.028 mg/L) (Exposition chronique au cuivre du consommateur liée à la teneur endogène des aliments et l'eau de boisson ($[Cu]_{médian}$ = 0.028 mg/L))

MS Diet	**Age (PRIMo)**	**Endogenous calculated Exposure to Copper in % ADI *via***		
		Drinking water (with [Cu] water = 0.028 ppm)	**Foods endogenous (Refined PRIMo)**	**Total**
IE adult	18-64	0,3	56,4	56,7
WHO Cluster diet B	na	0,3	55,2	55,5
UK Toddler	18 months - 4 years	0,9(1)	43,5	44,4
DK child	4-6	0,5	39,3	39,8
NL child	1-6	0,9(1)	38,4	39,3
WHO cluster diet D	na	0,3	33,8	34,1
UK Infant	6-12 months	1,0	33,1	34,1

(1) Worst case situation: water consumption of Toddler (12-35 months – Finland, DIPP) is considered.

According to this scenario, exposure to endogenous sources of copper remains acceptable.

Exposure to copper *via* treated crops

Considering the level of copper in "treated" commodities, the endogenous copper contents of foods, and using PRIMo, the chronic exposure to all the copper sources is detailed in the report Table VII. "Treated" crops are underlined.

Table VII : Chronic consumer exposure linked to treated crops and endogenous copper in foods (Exposition chronique au cuivre du consommateur liée aux cultures traitées et au niveau endogène des aliments)

Highest calculated TMDI values in % of ADI	**MS Diet**	**Highest contributor to MS diet (in % of ADI)**	**Commodity/ group of commodities**	**2nd contributor to MS diet (in % of ADI)**	**Commodity/ group of commodities**	**3rd contributor to MS diet (in % of ADI)**	**Commodity/ group of commodities**
89.7	WHO Cluster diet B	24.2	Wheat	8.3	Lettuce	5.1	Tomatoes
76.0	IE adult	12.5	Sheep: Liver	6.5	Wheat	3.8	Barley
73.2	NL child	13.5	Wheat	8.6	Spinach	6.0	Apples
63.9	DE child	11.7	Wheat	11.3	Apples	7.4	Table grapes
55.2	FR toddler	16.3	Spinach	7.4	Wheat	7.0	Leek
51.3	IT kids/toddler	18.9	Wheat	7.4	Other cereal	6.7	Lettuce
50.9	UK Toddler	19.1	Sugar beet (root)	11.1	Wheat	4.1	Beans

The highest chronic exposure was calculated for "WHO Cluster diet B" representing 89.7% ADI. This cluster includes general population diets from southern European countries (Portugal, Spain, Malta, Italy, Greece and Cyprus).
Considering the registered uses of copper, the first 2 diets remain the most critical ones, with a IEDI corresponding to 89.7% ADI for "WHO Cluster B" diet and to 76.0% ADI for "IE adult" diet.
One can notice that the main contributors to "treated crops exposure" to copper are cereals (highest exposure 24.2% ADI), sugar beet (19.1% ADI), spinach (16.3% ADI) and sheep liver (12.5% ADI). It should be noted that cereals are not subjected to copper treatments. However two treated crops appears as major contributors to "WHO Cluster B" diet: lettuce with 8.3% ADI and tomatoes with 5.1% ADI.
For "IE adult" diet, none of the treated crops appears in the 3 major contributors to exposure.
It appears that treated crops are generally not major contributors to exposure, except spinach for FR toddler diet.

Exposure to copper *via* treated crops and drinking water

As the pessimistic scenario has already led to chronic exposure to copper close or higher than ADI with endogenous copper in foods, addition of results from the treated crops was not considered.
A refined scenario results in the following exposures detailed in Table VIII:

Table VIII : Chronic consumer exposure linked to treated crops, endogenous copper in foods and drinking water ($[Cu]_{median}$ in France = 0.028 mg/L) (Exposition chronique au cuivre du consommateur liée aux cultures traitées, au niveau endogène des aliments et l'eau de boisson (($[Cu]_{médian}$ en France = 0.028 mg/L))

MS Diet (PRIMo)	**Age (PRIMo)**	**Highest calculated Exposure to Copper in % ADI *via***		
		Drinking water (with [Cu] water = 0.028 ppm)	**Foods (Refined PRIMo)**	**Total**
WHO Cluster diet B	na	0,3	89,7	90,0
IE adult	18-64	0,3	76,0	76,3
NL child	1-6	0,9(1)	73,2	74,1
DE child	2-below 5	0,9(1)	63,9	64,8
FR toddler	13-18 months	0,9	55,2	56,1
IT kids/toddler	1-17	0,9(1)	51,3	52,2
UK Toddler	18 months - 4 years	0,9(1)	50,9	51,9
DK child	4-6	0,5	50,9	51,3

(1) Worst case situation: water consumption of Toddler (12-35 months – Finland, DIPP) is considered.

This scenario leads to anacceptable chronic exposure to copper linked to the consumption of treated and not treated foods and drinking water.
The maximum exposure is identified for "WHO Cluster diet B" with 90% ADI. Foods are the major contributor and drinking water can be considered as negligeable.

DISCUSSION

Copper is present in all nearly all the food commodities, therefore to estimate the European consumer exposure to copper, it was necessary to quantified these background levels.The median endogenous levels of copper in commodities from plant and animal origins used in this study are based upon literature data. For all commodities with no data found in literature (30% of the commodities), the Guideline SANCO 7525/VI/95 – rev.9 for extrapolation from one crop to a group of crops was applied.
Despite a fine bibliography research, more than 80% of the crops have a limited data set available (less than 5 data points) (e.g. orange, potato, grapes, wheat). This leads to uncertainty to estimate the exposure to endogenous copper *via* foods. This lack of information may be due to the fact that copper is not often monitored in Europe.
The median level of copper in commodities of plant origin and of animal origin ranged between 0-25 mg/kg and 0-83 mg/kg respectively with higher residue levels in liver and kidney for animal matrices.

However, as no information was available about the origin of the crops used to generate the results found in the literature, it was not possible to determine wether the crop had been treated with copper as phytosanitary product or not.

The levels of copper in commodities of animal origin are consistent with the metabolism literature studies (SCAN, 2003). Indeed, as copper is not metabolized it was demonstrated that it tends to accumulate in liver and kidney and that in comparison the level of copper in others matrices (muscles, fat, milk and egg) would be low.

When considering endogenous levels of copper in crops only, exposure level was close to ADI, and already higher than ADI for UK infants and toddler and NL child when the regulatory scenario for water (2 mg Cu/L) is taken into account.

When copper foliar treatments were carried out according to the authorised GAP, the median level of copper in commodities of plant origin was between 0.3-350 mg/kg. The increase of the level of copper was the highest for leafy crops (hop, lettuce), leek and globe artichoke. Wheareas for other crops like closed tree nuts, citrus, pome fruits, stone fruits, bulb vegetable, root and tuber vegetables…, no significant increase was observed.

Copper is a contact funigicide. Then measuring the highest residue levels for leafy crops is consistent with the surface of the foliage exposed to the treatment. For closed tree nuts, as the fruit is protected inside the nut, no significant increase of copper is awaited even if the treatment is applied close to the harvest. When copper is applied when the fruit is not formed (most of treatments for arboriculture), then no copper in the fruit is awaited. Finally, considering bulb vegetables, roots and tubers, the fruit is protected under the soil. It is not exposed to the foliar copper treatment.

When considering endogenous levels of copper and the plant protection uses with a refined scenario for water (0.028 mg Cu/L), the exposure of all populations was below 90% of the ADI. On these bases, the intended uses of copper could be considered as acceptable.

Nevertheless, it should be kept in mind that for all the considered populations, tap water consumption is the most important contributor to exposure when the regulatory scenario (2 mg Cu/L) is considered. Exposure *via* water in this scenario is highly conservative as:

- the highest consumptions of water per class of age of the European population were taken into account;
- it was considered that only tap water was consumed (mineral water consumption not deduced);
- it is not realistic to use a maximum level of contamination to estimate the chronic risk over a life span but a median value is generally used;
- this tap water is always contaminated at the limit of 2 mg Cu/L. When data from SISE-Eaux database from French ministry of Health, over a period of 5 years were analysed, only 0.51% of all the data are higher than the maximum level of 2 mg Cu/L in tap water.

Therefore when considering median concentration of 0.028 mg Cu/L, tap water is not the most important contributor to exposure but contributes to less than 1% ADI.

Only French water contamination data could be taken into account in the framework of this evaluation. No water contamination data from other European MS were available. An underestimation of the contribution of risk associated to water is possible as the copper content of tap water and the corresponding regulations differ between MS.

For the treated crops that are major contributors to copper exposure (table grapes, apples, tomatoes, lettuces), and with the exception of lettuce, the effect of washing has not been assessed. Considering that copper is a contact fungicide, washing of those fruits and vegetables prior to consumption would most likely wash away surface copper linked to treatments and reduce consumer exposure. For wine grapes, it was demonstrated copper is present at low level in wine and is eliminated through the pomaces (EFSA, 2008).

On the other side, some uncertainties remain for the global exposure to copper because:

- copper is used in crop production as a fertilizer according to EU Regulation (EC) No 2003/2003. Then all crops can be fertilised with “copper containing fertilizers”, even close to harvest and no information is available concerning copper content of foods fertilised according to this legislation.

- copper is also part of many food supplementation products. Then some consumers could be exposed through food supplement consumption; which was not taken into account.
- copper being naturally present in all matrices, it is difficult to develop accurate analytical methods as no real controls are available. The limit of quantification (LOQ) for copper are generally high which is likely to overestimate the level of copper in some commodities.

Nevertheless, today, considering authorized uses as plant protection products, endogenous levels and water, 90% ADI was already reached, with 55% ADI linked to endogenous levels in food commodities (except water). The margin of safety remains low and copper concentration in tap water could be an issue. Moreover, it appears that a lot of uncertainties remain concerning consumer exposures to this compound. These are mainly linked to the large spectrum of uses of copper and the multiple ways of exposure for consumers: food supplement, level in potable water, uses as fertilizer, uses as plant protection product, veterinary uses, feed additive, biocide uses, etc.

A way to waive these uncertainties would be to included copper in the European pesticide monitoring annual plans, which would allow to conduct a more accurate exposure of consumers to copper.

CONCLUSION

An estimation of the European population chronic exposure to copper linked to ingestion (food and drinking water) was performed using both endogenous concentrations found in the public literature and data from phytopharmaceutical registration. Usually, in order to calculate the chronic exposure for a population linked to the ingestion of one active substance, only the residue levels of the treated crops are taken into account. For copper, because it is ubiquitous in foods and drinking water the residue level of copper in non-treated crops was also considered.

After refinement, the chronic risk for the European population linked to copper ingestion can be considered acceptable. Nevertheless, today, considering authorized uses as plant protection products, endogenous levels and drinking water, 90% ADI is already reached, with 55% ADI linked to endogenous levels in food commodities (except water). The margin of safety remains low and a significant level of uncertainties was noted. Further data would be necessary for both food and water at the EU level.

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