



ARSENIC AND WINE: A REVIEW



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SCOPE

The group of experts « Food safety » of the OIV has worked extensively on the safety assessment of different compounds found in vitivincultural products.

This document aims to gather more specific information on arsenic. This document has been prepared taking into consideration the information provide during the different sessions of the group of experts “Food safety” and information that provided by Member States.

Finally, this document, drafted and developed on the initiative of the OIV, is a collective expert report. This review is based on the help of scientific literature and technical works available until date of publishing.

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INTRODUCTION

The presence of arsenic in soil, food and drink has been known for many years, and associated with different sources. The Member-states of the OIV are concerned about arsenic in wines and have established a limit of 200 µg/L.

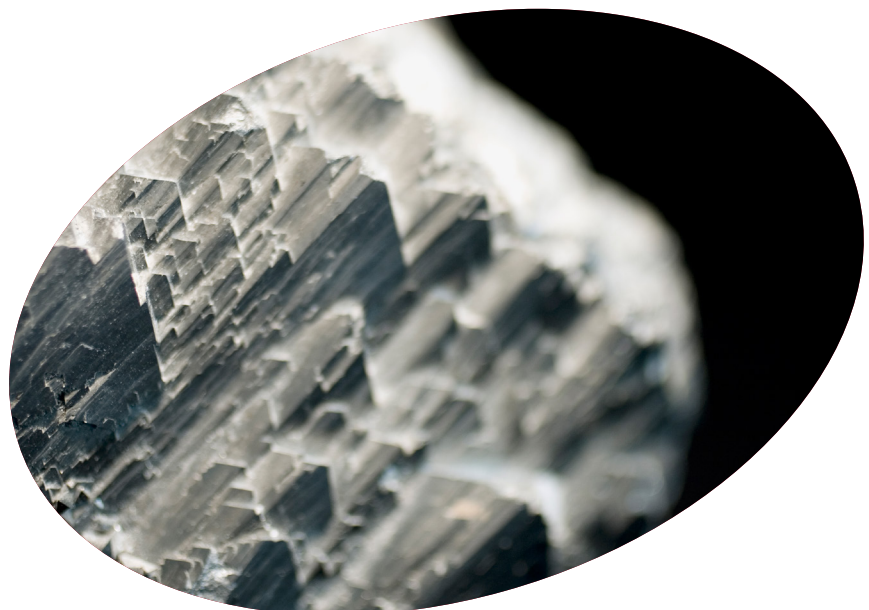
During the last meeting of the OIV Food safety group, in the framework of the identification of contaminants/toxins in wine having potential health consequences, an eWG was established for preparing a working document on “arsenic” coordinated by France and including Australia, Germany, Italy, Argentina, Spain and the OIV.

This document analyses the different emerging toxicological issues and in particular the levels of arsenic in food and wines.

The OIV working group prepared this document also in response to the new toxicological evaluation of arsenic in food. In fact, the provisional guideline level for drinking water of 10 mg/L, allowed a definition by JECFA (FAO/WHO Expert Committee on Food Additives) of a PTWI (Provisional tolerable weekly intake) of 15 mg/kg b.w. assuming a consumption of 20% to drinking water.

During the revision of assessment, JECFA concluded that the former value of PTWI for inorganic As (arsenic) could not longer considered health-protective. Therefore, this PTWI has been withdrawn.

Data reported in this document are collected from different available sources and some data on arsenic levels are provided by the OIV Member States in reply to a circular letter sent directly to the contact government of the OIV Member States.





Chemistry of Arsenic

The CAS number of arsenic is 7440-38-2; it is a metalloid naturally present at high levels in the groundwater of a number of countries, so that As can be found in water, soil, and air from natural sources to which anthropogenic activities must be added. It exists in inorganic and organic forms and in different oxidation states (-3, 0, +3, +5). In the case of environmental exposure, toxicologists are primarily concerned with arsenic in the trivalent and pentavalent oxidation state and arsenic is highly toxic in its inorganic form. The more commonly known arsenic compounds, arsenate and arsenite, are the anionic forms of arsenic acid and arsenous acid, respectively. Monomethylarsonic acid (MMAV) and dimethylarsinic acid (DMAV) are stable methylated mammalian metabolites of inorganic arsenic and are primarily excreted in the urine. It must be mentioned that DMAV and the sodium salts of MMAV have been used as herbicides.

Sources of Arsenic

As is a metalloid that is present in the earth crust at levels as high as 3.4 mg kg⁻¹ and it can be found in different concentration ranges in drinking water, soil, air, food, plants and animals [1]. Arsenic sources being both natural and man-made, exposure can be varied through every medium including air, water, soil, food including as well as plants and fertilizer. Arsenic is widely distributed throughout the earth's crust, generally as arsenic sulfide or as metal arsenates and arsenides. In water, arsenic occurs in one of two main forms: arsenite As(III) under reducing conditions and arsenate As(V) if the water is oxygenated. It can be released to the atmosphere, primarily as the trioxide, mainly by high-temperature processes or through volatilization from aerated soils. In the atmosphere, it is mainly adsorbed on particles, which are dispersed by winds and deposited on land and water. Arsenic can be released into the atmosphere and water in the following ways:

- natural activities, such as volcanic activity, dissolution or desorption of minerals (particularly into groundwater), exudates from vegetation and wind-blown dusts;
- human activities, such as metal smelting, combustion of fossil fuels (especially coal), mining, timber treatment with preservatives, and, historically, agricultural pesticide production and use;
- remobilization of historic sources, such as mine drainage water; and
- mobilization into drinking-water from geological deposits by drilling of tube wells¹.

In the superficial part of the earth's crust, the average arsenic concentration is evaluated at 2 mg/kg. Locally, the natural concentration can reach 100 mg/kg or even 200 mg/kg in calcareous deposits or phosphates and in shale. It is present as impurity in many areas, it is a byproduct of the metallurgy of Cu, Pb, Zn, Sn and Au. Poison par excellence, arsenic has a high toxicological potential. Mineral derivatives are used as insecticides, fungicides. Arsenic has different metallurgical applications, but it is also used in glassmaking and microelectronics. In the building its main application is the treatment of wood. Environmental impacts of arsenic include acid rain, eutrophication, haze, effect on wildlife, ozone depletion, crop and forest damage and global climate change. The treatment methods used for arsenic removal include physical, chemical and biological methods. The physical treatment methods are mainly based on ion exchange, ultrafiltration, coagulation and flocculation, flotation, while chemical treatment methods use sorption, electro-chemical treatment, electro-coagulation, electro-flotation, electro-deposition, nanofiltration, activated carbon adsorbents, carbon nanotubes adsorbents, low-cost adsorbents. Biological treatment methods such as phytoremediation, microbial reduction, reverse osmosis, bioadsorbents and membrane filtration have been also used. Data on distribution of arsenicosis are illustrated in Figure 1.

¹Exposure to arsenic: a major public health concern, WHO, <https://apps.who.int/iris/bitstream/handle/10665/329482/WHO-CED-PHE-EPE-19.4.1-eng.pdf?ua=1>

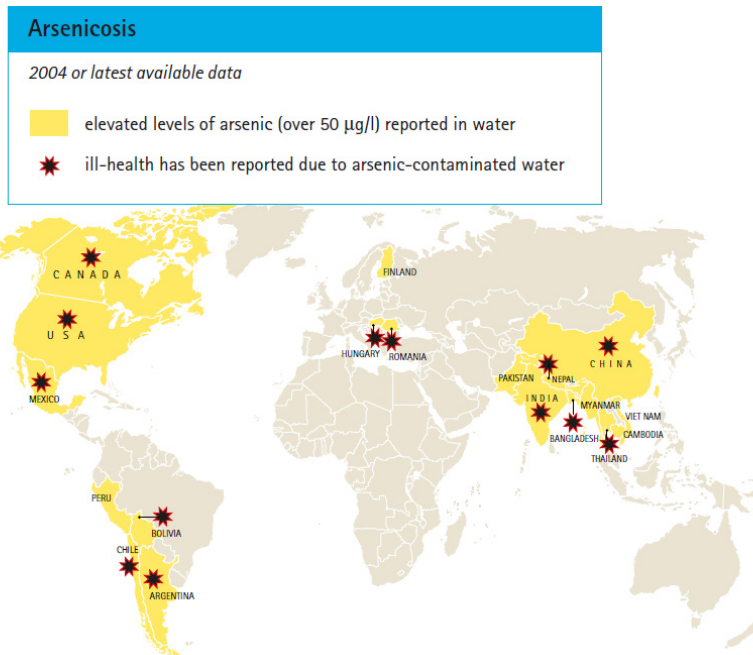


Figure 1: Global situation of arsenicosis 2004²

Levels of Arsenic in Food

Food and drinking water are the principal routes of exposure to arsenic (WHO, 2011a; IARC, 2012) and Figure 2 illustrates the range of content in the main contributors.

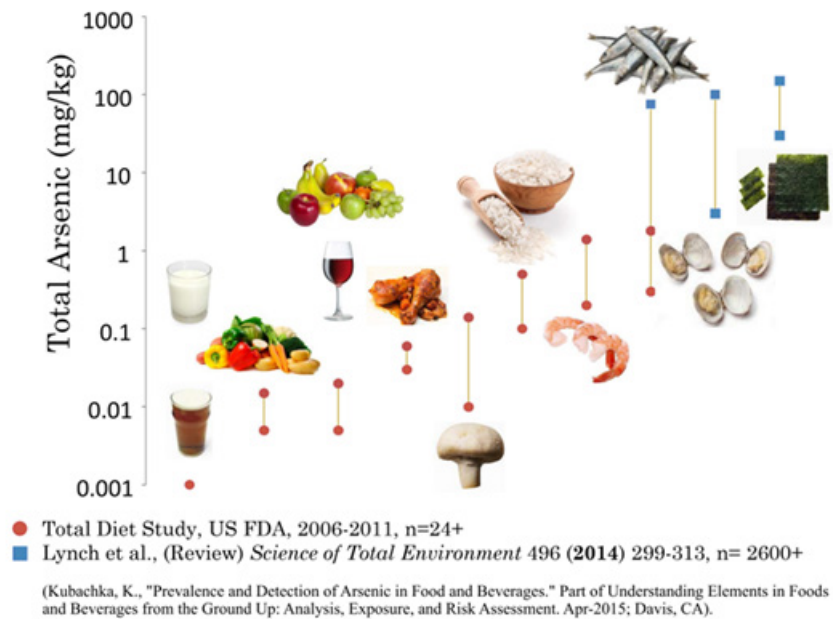


Figure 2: Contribution of food to As intake

²www.who.int/entity/ceh/publications/en/08fl_uor.pdf



Total As and iAs contents of 215 food products and drinks (i.e. seafood, fruits and vegetables, meat products, oils and fats, rice and rice products, seasonings and alcoholic drinks) marketed in Catalonia (Spain) were quantified (Fontcuberta et al. (2011)).

Daily As and iAs intakes for the average adult Catalan consumer were estimated at 354 and 6.1 µg/day/person, respectively, using consumption data from the Catalan Nutrition Survey (ENCAT). The highest As content was found in seafood, contributing 96% of dietary As intake, whereas rice presented the highest iAs values, corresponding to 67% of dietary iAs intake. Dietary habits of a individuals residing in Northern Italy (Filippini et al., (2018)) show that fish was the main contributor to As and Hg intake.

The highest levels of As were in sardine, sole/flounder and cephalopods, and of Hg in the biggest, predatory fish. About the other foods, cereals were the second contributor to the intake of these elements, especially rice for As and bread for Hg, and high levels of As and Hg were also found in mushrooms, coffee and wine. Average weekly intake of both contaminants was below recommended safety limits.

In 2015, the EFSA report indicates estimated inorganic arsenic levels in certain foods and drinking water, and human dietary exposure estimated on the basis of high consumption of these foods.³ Level of arsenic contamination in different beverages in USA and Europe are listed in Table 1 and 2.

Table 1 - Level of arsenic contamination in different beverages in Europe

Foods and drinks	Estimated levels in food (µg/kg)*	Arsenic intake in food (µg/kg bm/day)*
<i>Highly consumed foods</i>		
Liquid milk	4.1	0.05
Wheat bread and rolls	14.3	0.06
Soft drinks	6.9	0.13
Beer	6.8	0.25
Drinking water	2.1	0.08
<i>Foods with higher arsenic levels</i>		
White rice	88.7	0.23
Brown rice	151.9	0.38
<i>Selected other foods</i>		
Fish meat	11.3	0.03
Crustaceans	36.2	0.06
Molluscs	50.9	0.10

* Key: Estimates may vary by +/- 40% in most food categories but by less, around +/-10%, for rice. These figures are derived from samples using a statistical tool called the "substitution method".

³http://www.efsa.europa.eu/sites/default/files/corporate_publications/files/chemfood15.pdf



Table 2 - Level of arsenic contamination in different beverages in USA

Beverage	Arsenic Type	Contamination (ppb) ^a			% of U.S. EPA MCL ^a		
		Min	Mean	Max	Min	Mean	Max
Cider (apple) ^b	Total arsenic	5.4	10	15	54	100	150
	Inorganic arsenic	3.9	9.7	15	39	97	150
Juice (apple) ^b	Total arsenic	11	18	30	110	180	300
	Inorganic arsenic	6.9	15	25	69	150	250
Juice (apple) ^c	Primarily inorganic	3.7	7.5	13	37	75	130
Juice (apple blend) ^c	Primarily inorganic	3.5	9.2	20	35	92	200
Juice (grape) ^{b*}	Total arsenic	7.0	22	48*	70	220	480
	Inorganic arsenic	5.2	20	51*	52	200	510
Milk ^b	Total arsenic	2.6	2.7	2.8	26	27	28
	Inorganic arsenic	0.45	0.96	2.0	4.5	9.6	20
Water (bottled) ^d	Total arsenic	0.08	0.62	1.9	0.8	6.2	19
Wine ^e	Primarily inorganic	10	23	76	100	230	760

^a ppb = parts per billion; U.S. EPA MCL = U.S. Environmental Protection Agency maximum contaminant limit.

^b Roberge et al., 2009.

^c Wilson et al., 2012.

^d Sullivan & Leary, 2011.

^e Wilson, 2015.

* Computed from mean values of multiple batches; variance within mean values may cause max inorganic arsenic to exceed max total arsenic.

Issue from Denise Wilson, October 2015 • Journal of Environmental Health⁴

EFSA reported the estimated iAs levels in the food category 'Alcoholic beverages'⁵ as illustrated in Table 3.

Table 3 - Estimated iAs concentration in alcoholic beverages

FOODEX_NAME	Mean estimated iAs (µg/kg)					
	N ^(a)	LC % ^(b)	LB	MB	UB	Groups
ALCOHOLIC BEVERAGES	2005					
Beer and beer-like beverage	656	72	3.1	6.8	10.5	Alcoholic beverages
Wine	1047	53	3.9	5.8	7.6	
Fortified and liqueur wines	24	13	8.1	8.2	8.4	
Spirits	36	78	0.2	1.1	1.9	
Alcoholic mixed drinks	96	55	3.9	5.3	6.7	
Liqueur	16	88	2.6	5.5	8.3	
Wine-like drinks (e.g. Cider, Perry)	119					
Cider	40	48	2.7	3.1	3.6	
Wine-like drinks (e.g. Cider, Perry) (unspecified)	79	29	10.1	10.4	10.8	
Alcoholic beverages (unspecified)	11	100	0.0	4.6	9.2	

⁴ Denise Wilson, October 2015 • Journal of Environmental Health

⁵ <https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2014.3597>



ARSENIC LEVEL IN WINES

Arsenic could be present in widely consumed alcoholic beverages, such as wine, due to the use of contaminated herbicides or insecticides to vine plants. Other potential sources of As contamination for grape/wines include, soil type, water quality used for watering where applicable and the several procedures applied during winemaking, i.e. harvesting, crushing and pressing, fermentation, purification and storage conditions of the final product [5]. Finally the water used to clean bottle could contribute to the total As measured in wine. Different papers indicate the content of As in wine from different geographical areas. According to Tanabe et al. (2016), the total As content in white, rosé, red, Port, and sparkling wines was <LOQ (0.38 µg/L - 43.8 µg/L) Wilson et al. (2015) analysed 65 wines obtaining the following As concentrations: mean 23.3 µg/L; range: 10-76 µg/L. Paustenbach et al, (2016) reported data on 101 wines as illustrated in Table 4, while data on 147 red wines by Vacchina et al. (2016) are listed in Table 5.

Table 4 – Total As concentration in wines as reported by Pausternbach et al (2016)

Wine Sample Group	Wine Type	n	Detection Frequency ^a	Mean ± SD (µg/L)	Geometric Mean (µg/L) [GSD (unitless)] ^b	Median (µg/L)	5 th Percentile-95 th Percentile (µg/L)
Random selection of California wines	Red	31	42%	3.62±4.24	2.09 [2.71] ^{c,d}	<2.00	<2.00 - 11.8
	White	32	75%	6.99±7.87	4.13 [2.90] ^{c,d}	4.86	<2.00 - 22.8
	Blush	10	100%	20.5±18.0	16.1 [2.01] ^{c,d}	17.8	6.90 - 49.3
Publicised California Wines based on Media reports	Red	9	100%	17.5±5.13	16.8 [1.36] ^{c,e}	17.2	10.7 - 24.8
	White	9	100%	24.6±9.75	22.7 [1.57] ^{c,e}	28.9	11.5 - 36.4
	Blush	10	100%	33.8±13.4	31.7 [1.45] ^{c,e}	29.4	20.5 - 56.1

^a MRL was 2.00 µg/L; non-detects were treated as ½ MRL for this analysis

^b GSD = geometric standard deviation

^c Publicised wines contained significantly more As than random wines (p = 2.4x10⁻¹⁹)

^d Within random wines: the blush to white p-value = 9.5x10⁻⁵, the blush to red p-value = 3.3x10⁻⁷ and the white to red p-value = 0.011

^e Within publicised wines: the blush to white p-value = 0.10, the blush to red p-value = 0.00082 and the white to red p-value = 0.12



Table 5 – Data on 147 red wines reported by Vacchina et al. (2016)

Origin	Number of samples in the range (range expressed in µg As/L)																	
	Total As				As(III)				DMA			MMA			As(V)			
	0.1– <0.1	0.5– 5	10– 10	60– 60	0.3– <0.3	5– 5	10– 10	50– 50	0.15– <0.15	0.4– 0.4	3– 3	0.3– <0.3	1– 1	2– 2	0.2– <0.2	5– 5	10– 10	15– 15
Bordeaux (n = 38)	0	30	7	1	1	35	1	1	12	7	19	36	1	1	8	30	0	0
France other (n = 38)	0	31	4	3	3	28	5	2	26	8	4	37	1	0	9	27	1	1
Iberian Peninsula (n = 6)	0	6	0	0	0	6	0	0	3	3	0	6	0	0	3	3	0	0
Italy (n = 4)	0	3	1	0	1	2	1	0	2	1	1	4	0	0	0	4	0	0
Greece (n = 5)	0	5	0	0	0	5	0	0	5	0	0	5	0	0	0	5	0	0
Slovenia (n = 7)	0	7	0	0	3	4	0	0	6	0	1	7	0	0	0	7	0	0
United States (n = 26)	0	17	4	5	1	18	3	4	13	3	10	25	1	0	4	21	1	0
Maghreb (n = 7)	1	6	0	0	1	6	0	0	5	2	0	7	0	0	1	6	0	0
South Africa (n = 2)	1	1	0	0	1	1	0	0	2	0	0	2	0	0	1	1	0	0
Chile	0	7	0	0	0	7	0	0	6	0	1	7	0	0	4	3	0	0
Argentina (n = 3)	0	2	1	0	0	3	0	0	1	0	2	3	0	0	0	3	0	0
Australia (n = 3)	0	3	0	0	1	2	0	0	3	0	0	3	0	0	2	1	0	0
China (n = 1)	0	0	0	1	0	0	0	1	1	0	0	1	0	0	0	1	0	0



Figure 3 illustrates the total As concentration in wine samples using the Boxplot representation. Data are in function of the geographical origin of the samples (note that only the groups accounting at least three samples were considered).

The dots represent the outliers. Results indicated that the Total As concentration: in 75% of the samples, was <4.3 µg/L, and for 93% of the samples, <10 µg/L. (Vacchina et al. (2016)).

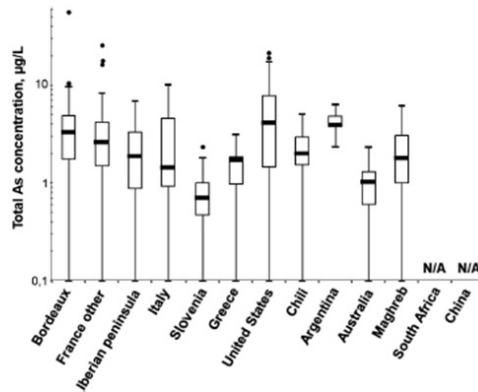


Figure 3 - Total As concentration in wine samples in function of the geographical origin (Vacchina et al. (2016))

WHO GEMS/Food database on Arsenic levels in wine

Table 11 shows data reported by WHO GEMS/Food Database where the maximum and minimum of Arsenic levels in wine are between 0.3 and 101 mg/L. As concentration in white is higher (+16,5%) than that in red wines.

The average level of Arsenic in wine 12.22 µg/L is close to the provisional WHO water level (10 µg/L).

Table 11 - Arsenic levels in wine from WHO Gems Food Database (2003-2015)

Countries	Number of samples	Average Level µg/L	Standard deviation µg/L	Minimum µg/L	Maximum µg/L
Australia	37	10.7391	6.1586	3.0000	29.0000
Belgium	15			0.0000	0.0000
Czech Republic	22	6.4299	3.1552	3.0278	16.1000
France	62	12.0481	19.5877	1.0000	101.0000
Germany	1091	11.7140	8.2718	0.3000	67.5000
HONG KONG SAR	4	5.6667	1.1547	5.0000	7.0000
Ireland	2	5.0000	0.0000	5.0000	5.0000
New Zealand	16	4.2500	2.8402	1.0000	10.0000
Slovakia	133	21.4545	16.7879	3.0000	63.0000
USA	32	10.2500	3.6860	6.0000	18.0000
WHO European Region	396	14.0769	11.2866	3.0280	67.0000
<i>Wine</i>	201	14.3001	11.2322	3.0280	67.0000
<i>Wine. red</i>	59	11.9692	4.6713	5.0000	16.6000
<i>Wine. white</i>	102	14.3500	12.6504	4.0000	63.0000
<i>Wine. white. sparkling</i>	30			0.0000	0.0000
<i>Wine. red. sparkling</i>	4			0.0000	0.0000
Total	1810	12.2282	10.0569	0.3000	101.0000

**As levels in wines: data from OIV Member States** **Argentina**

Data from Argentina are related to the period from 2013 to 09-10-2018 (Table 6). In Argentina the allowed limit is 0.20 mg/L.

Table 6 – Data reported by Argentina in the period 2013-2018

Informed result	N° Samples	%
not detected	50744	93,87%
< 0,10 mg/L	1357	2,51%
< 0,20 mg/L	1959	3,62%
total	54060	100%

 **Australia**

Data on total As content in wines sent from Australia are reported in Table 7.

Table 7 – Total As (µg/L) content in wines coming from different Australian areas

State	Region	Colour	N. of Samples	Median	Maximum	Minimum
	Canberra District	Red	4	0.6	0.7	0.4
	Hilltops	Red	4	0.8	1.0	0.6
New South Wales	Hunter Valley	Red	9	1.2	14.8	0.9
		White	31	5.6	12.7	1.9
	Mudgee	Red	4	1.2	3.9	0.6
		White	5	3.5	6.9	2.7
	Orange	Red	10	1.0	10.6	0.6
		White	7	2.8	3.2	2.0
	Riverina	Red	3	1.2	3.7	1.0
	Tumbarumba	Red	3	2.2	3.8	0.5
White		3	3.5	7.2	2.7	
Queensland	Granite Belt	Red	7	1.0	3.4	0.5
		White	4	5.2	8.4	1.4
South Australia	Adelaide Hills	Red	20	1.5	7.4	0.2
		White	45	4.7	33.6	1.9
	Adelaide Plains	Red	4	2.9	17.6	1.0
	Barossa Vale	Red	61	1.7	13.4	0.4
		White	20	7.0	11.4	1.8
	Clare Valley	Red	25	1.7	70.4	0.6
		White	25	4.3	18.7	1.1
	Coonawarra	Red	36	3.5	17.7	1.0
		White	5	5.4	7.2	1.6
	Eden Valley	Red	13	3.3	4.7	0.7
White		28	4.6	13.5	1.5	
Langhorne Creek	Red	23	2.9	9.4	0.6	
	White	57	2.0	23.1	0.8	
Tasmania	McLaren Vale	Red	16	6.2	13.5	2.1
		White	14	0.6	2.5	0.2
		Red	14	0.6	2.5	0.2
		White	14	2.5	4.5	1.3
Victoria	Geelong	Red	6	1.3	5.0	0.7
		White	3	6.3	12.5	4.7
	Grampians	Red	4	1.0	1.3	0.7
	Heathcote	White	10	2.5	7.6	0.4
	King Valley	Red	3	2.1	6.7	1.4
		White	3	4.8	7.4	4.3
	Macedon Ranges	Red	3	0.7	1.0	0.6
		White	3	7.4	10.8	6.1
	Mornington Peninsula	Red	15	0.9	6.2	0.5
		White	11	3.3	7.3	1.4
	Pyrenees	Red	8	1.2	8.7	0.4
		White	4	3.2	4.9	2.0
	Yarra Valley	Red	44	1.4	21.8	0.2
		White	23	4.3	15.2	1.4



 **Portugal**

Portugal sent data on the total As content in wines analysed in the period 2002- 2019 (Table 8).

Table 8 – Total As concentration in a sample of Portugal wines from 2020-2019

Wine	Number of samples	Maximum value (mg/L)
Wine with AOP	293	< 0.05
Liqueur with AOP	91	< 0.05
Wines without AOP	18	< 0.05

 **Spain**

Data from Spain are reported in Table 9.

Table 9 – Total As concentration in 380 wine samples from Spain

			Results > LoQ (mg/kg) N° samples: 20			
Total samples	Samples < LoQ	% samples < LoQ	Mean	Median	Min	Max
380	360	95	0.013	0.012	0.01	0.021

 **Slovak Republic**

Official analyses on total arsenic content in wines from Slovakia has been carried out during the period 1993-1995; the arsenic content was always under the limit of detection LOQ. For 30 samples of 2018 analysed by AAS method and coming from the regions where the arsenic content in the soil is particularly high, the total arsenic content was in the range 1.5-7.0 µg/L.

 **South Africa**

Data sent from South Africa are reported in Table 10.

Table 10 – Total As concentration in 1807 samples from South Africa

			Results > LoQ (mg/kg) N° samples: 10			
Total samples	Samples < LoQ	% samples < LoQ	Mean	Median	Min	Max
1807	1797	99.4	0.005	0.001	0.0004	0.020



LIMITS IN FOOD AND BEVERAGES

Maximum limits (ML) for arsenic have not been established except for water intended for human consumption, where a value of 10 µg/L has been established without distinguishing arsenic forms; for natural mineral waters, a ML of 10 µg/L is laid down for total arsenic (tAs).

The U.S. Environmental Protection Agency (U.S. EPA) set the same arsenic maximum contaminant level (MCL) of 10 µg/L for public water supplies. The EPA also established the MCL Goal (MCLG) for drinking water, at a level suitable to prevent potential health problems and set this value at zero.

The current recommended limit of arsenic in drinking-water of 10 µg/L is designated as provisional because of practical difficulties in removing arsenic from drinking-water. Every effort should therefore be made to keep concentrations as low as reasonably possible and below the guideline value when resources are available.

Several countries including Canada and the OIV have set limits of arsenic in wine ranging from 100 to 200 µg/L corresponding to 10-20 times the level set for drinking water^{6,7}.

SAFETY ASPECTS

General aspects

Several possible impacts of As intake on human health have been reported; the exposure to As is considered a risk factor for cancer, neurobehavioral and neuropathic effects, effects on memory and intellectual function, reproductive effects. There is evidence that drinking water with elevated levels of arsenic is associated with the development of cancer, although the mechanism of carcinogenicity and the effects at low intakes are still unclear. The International Programme on Chemical Safety (IPCS) concluded that long-term exposure to arsenic in drinking-water is causally related to increased risks of cancer in the skin, lungs, bladder and kidney, as well as other skin changes (WHO, 2001).

The toxicity of As strongly depends on its chemical characteristics and speciation, with inorganic species being more toxic than organic ones [2]. In other words, the total concentration of As present in food or beverages does not provide conclusive information about the real toxicological risk for consumers.

Consequently, the development of modern methodologies for As speciation analysis is mandatory, and this is particularly important when food typically consumed in human diet are considered [3], [4].

Pentavalent and trivalent soluble arsenic compounds are rapidly absorbed from the human gastrointestinal tract and are metabolized by the reduction of pentavalent to trivalent arsenic and by the oxidative methylation of trivalent arsenic to monomethylated, dimethylated and trimethylated products. Methylation, modifying the chemical nature of the metalloid, increases the excretion of inorganic from the body, as the end-products are readily excreted in urine. Ingested organic arsenic compounds are less extensively metabolized and more rapidly eliminated in urine than inorganic arsenic.

The acute toxicity of arsenic compounds in humans is mainly due to their rate of excretion; in decreasing order of toxicity there are: arsine, arsenites, arsenates and organic arsenic compounds. Acute arsenic intoxication has been observed with the intake of drinking water containing high As concentrations (approximately 21.0 mg/L).

Signs of chronic arsenicism, including dermal lesions such as hyperpigmentation and hypopigmentation, peripheral neuropathy, skin cancer, bladder and lung cancers and peripheral vascular disease, have been observed in populations ingesting arsenic-contaminated drinking-water, while cardiovascular problems were mainly observed in children drinking arsenic-contaminated water (mean concentration 0.6 mg/L) for an average of 7 years. In utero and early childhood exposure has been linked to negative impacts on cognitive development and increased deaths in young adults. The most important action in affected communities is the prevention of further exposure to arsenic by provision of a safe water and food supply.

⁶ Health Canada Santé Canada Guidelines for Canadian Drinking Water Quality: Guideline Technical Document

⁷ OIV, Compendium of International Methods of analysis, Annex C



Safety assessment

Arsenic and arsenic compounds were considered by the International Agency for Research on Cancer (IARC) in 1980, 1987, 2007 and 2012. In the latest evaluation⁸, IARC indicated that there is sufficient evidence in humans for the carcinogenicity of mixed exposure to inorganic arsenic compounds, including arsenic trioxide, arsenite, and arsenate. Inorganic arsenic compounds, including arsenic trioxide, arsenite, and arsenate, cause cancer of the lung, urinary bladder, and skin.

Also, a positive association has been observed between exposure to arsenic and inorganic arsenic compounds and cancer of the kidney, liver, and prostate.

In view of the overall findings in animals, there is sufficient evidence in experimental animals for the carcinogenicity of inorganic arsenic compounds. Arsenic and inorganic arsenic compounds are carcinogenic to humans (Group 1).

The IARC considered also that considering elemental arsenic and inorganic arsenic species share the same metabolic pathway:

arsenate → arsenite → methylarsonate → dimethylarsenite.

Thus, independent of the mechanisms of the carcinogenic action, and independent of which of the metabolites is the actual ultimate carcinogen, all inorganic arsenic species should be considered as carcinogenic.

IARC (2004)⁹ also considers that arsenic in drinking water is carcinogenic to humans (Group 1), since there is sufficient evidence that arsenic in drinking water causes cancer of the bladder, lung and skin.

In 2011, the Joint FAO/WHO Expert Committee on Food Additives (JECFA)¹⁰ was asked to consider all information related to the toxicology and epidemiology, exposure assessment, including biomarker studies, analytical methodology, speciation and occurrence in food and drinking-water, in order to re-evaluate and review the PTWI for inorganic arsenic. The previous provisional guideline value of 10 g/L for drinking water was based on the PTWI of 15 µg/kg body weight, assuming an allocation of 20% to drinking water. During revision, JECFA concluded that the existing PTWI was very close to the lower confidence limit on the benchmark dose for a 0.5% response (BMDL0.5) calculated from epidemiological studies and was therefore no longer appropriate. The old PTWI was therefore withdrawn. Unfortunately, in many countries, even the previous provisional guideline value may not be attainable, so that many effort must be made to reduce the intake of As as much as possible.

⁸IARC Working Group on the Evaluation of Carcinogenic Risks to Humans, A Review of Human Carcinogens: Arsenic, Metals, Fibres, and Dusts. IARC monographs on the evaluation of carcinogenic risks to humans, Vol. 100C. Lyon : International Agency for Research on Cancer. (2012). <http://monographs.iarc.fr/> <http://monographs.iarc.fr/ENG/Monographs/vol100C/mono100C.pdf>

⁹IARC Working Group on the Evaluation of Carcinogenic Risks to Humans, Some drinking-water disinfectants and contaminants, including arsenic. IARC monographs on the evaluation of carcinogenic risks to humans, Vol. 84. Lyon : International Agency for Research on Cancer. (2004). <https://monographs.iarc.fr/wp-content/uploads/2018/06/mono84.pdf> <http://monographs.iarc.fr/>

¹⁰WHO 2011 : Evaluation of certain contaminants in food: seventy-second report of the Joint FAO/WHO Expert Committee. WHO technical report series ; no. 959. ISBN 978 92 4 120959 5. Available online: https://apps.who.int/iris/bitstream/handle/10665/44514/WHO_TRS_959_eng.pdf?jsessionid=C790E774E357384C5E9445287A01B293?sequence=1 on Food Additives.



In 2009^{11, 12} a scientific opinion on arsenic in food has been published by the European Food Safety Authority (EFSA) which concluded they could not set a safe level of arsenic in food.

However, they estimated the dose range within which arsenic is likely to cause a small but measurable effect on a human body organ. This is called the Benchmark Dose (BMD) and was set at 0.3 to 8 micrograms per kilogram of body weight per day ($\mu\text{g}/\text{kg b.w./day}$) for an increased risk of cancer of the lung, skin and bladder, as well as skin lesions. This reference range is not a “safe level” for arsenic as such but it helps the reader to understand that the figures on arsenic levels in food and dietary exposure in the EU should be as much as possible below the lower end of this range.

In 2014¹³, EFSA updated its analysis of arsenic levels in food in Europe and its estimates of exposure to inorganic arsenic in food and drinking water. Overall, the new estimates of dietary exposure to inorganic arsenic are lower than those reported in 2009; however, the upper estimates sometimes exceed the reference point for potential health effects indicated by EFSA in 2009.

The EFSA noted that, since the provisional tolerable weekly intake (PTWI) of $15 \mu\text{g}/\text{kg b.w.}$ was established by the Joint FAO/WHO Expert Committee on Food Additives (JECFA), new data had established that inorganic arsenic causes cancer of the lung and urinary tract in addition to skin, and that a range of adverse effects had been reported at exposures lower than those reviewed by the JECFA. Therefore, the CONTAM Panel concluded that the JECFA PTWI of $15 \mu\text{g}/\text{kg b.w.}$ was no longer appropriate and, in its assessment, focussed on more recent data showing effects at lower doses of inorganic arsenic than those considered by the JECFA.

¹¹Chemicals in food 2015 – Overview of Data Collection Reports. doi: 10.2805/578414.

http://www.efsa.europa.eu/sites/default/files/corporate_publications/files/chemfood15.pdf

¹²EFSA Panel on Contaminants in the Food Chain (CONTAM); Scientific Opinion on Arsenic in Food. EFSA Journal 2009; 7(10):1351. [199 pp.]. doi:10.2903/j.efsa.2009.1351. Available online: <https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2009.1351>

¹³ Dietary exposure to inorganic arsenic in the European population EFSA Journal 2014;12(3):3597 <https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2014.3597>



ESTIMATED INTAKE

Information on exposure to arsenic due to food and beverage intake

Considering data on exposure to As, infants, toddlers and other children were the groups of population showing the high dietary intake (Figure 4). Arsenic levels found in each food type and the consumption levels for these foods, among the various age groups, are the main factors influencing dietary exposure. In addition, dietary exposure is calculated on a body weight basis, which is an important reason why children often have the highest exposure levels to arsenic and other chemicals in food.

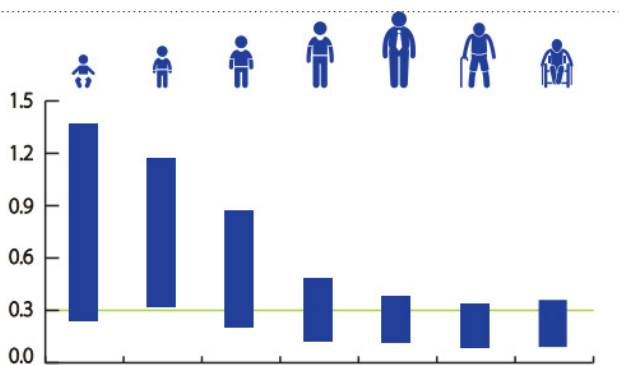


Figure 4 – Exposure to dietary As in different age groups (EFSA, 2014)

A total of 103 773 food samples (including drinking water) were used to calculate dietary exposure to inorganic arsenic (iAs). Of these, 101 020 were based on total arsenic (tAs) and 2 753 on iAs. Among the reported results on tAs, 66.1 % were below the limit of detection or quantification (left-censored); for the reported data on iAs the percentage of left-censored data was 41.9 %. Most of the data (92.5 %) reported as tAs were converted to iAs using different approaches before calculating dietary exposure to iAs. The EFSA Comprehensive European Food Consumption Database was used to estimate chronic dietary exposure to iAs using 28 surveys from 17 European countries. According to the scenarios used for the treatment of left-censored data, average exposure ranged from 0.20 to 1.37 micrograms per kilogram of body weight per day ($\mu\text{g}/\text{kg b.w./day}$), with high exposure from 0.36 to 2.09 $\mu\text{g}/\text{kg b.w./day}$. Average dietary exposure among adults ranged from 0.09 to 0.38 $\mu\text{g}/\text{kg b.w./day}$. This includes the “elderly” (65-75 years old) and the very elderly (75+). Estimates of high exposure for adults ranged from 0.14 to 0.64 $\mu\text{g}/\text{kg b.w./day}$.

For all the age classes except infants and toddlers, the main contributor to dietary exposure to iAs was the food group ‘Grain-based processed products (non rice-based)’, in particular, wheat bread and rolls. Other food groups that were important contributors to iAs exposure were rice, milk and dairy products (main contributor in infants and toddlers) and drinking water.

The most important sources of uncertainty in the present assessment are related to the heterogeneity of the food consumption data, the conversion of tAs into iAs and to the treatment of the left-censored data.

Figure 5 describes the contribution of each food category, expressed in $\mu\text{g}/\text{kg b.w. per day}$, to the overall total arsenic exposure, and inorganic arsenic by using the adjusted upper and lower bound mean values from the occurrence data.

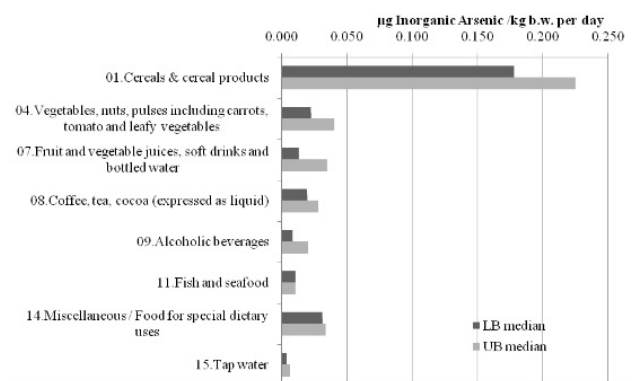


Figure 5 – Estimated country median consumer exposure to inorganic arsenic by different food groups (EFSA, 2014)

Figure 4 and 5 reflect the assumptions made on the selection of the food categories considered as the main contributors to the inorganic arsenic daily intake. Apart “from cereal and cereal products”, and “fish and seafood” already mentioned, on the basis of the EFSA Concise Food Consumption Database the food categories of “all vegetables, nuts and pulses”, “fruit and vegetable juices, soft drinks and bottled water”, “coffee, tea and cocoa”, “alcoholic beverages”, “miscellaneous food and food for special dietary uses” are major contributors to the overall exposure to total arsenic. Although “tap water” does not highly contribute to the total arsenic intake, its arsenic content is mainly represented by inorganic arsenic and therefore considered important for a possible exposure assessment.



METHODS OF ANALYSIS ADOPTED BY THE OIV FOR WINE

Two specific methods for the determination of arsenic in wine have been adopted by the OIV.

1. The principle of the method

OIV-MA-AS323-01A is based on the determination of arsenic in wine by atomic absorption spectrometer. After evaporating ethyl alcohol and reducing the arsenic V in arsenic III, wine arsenic is measured by hydride generation and by atomic absorption spectrometry;

2. The principle of the second method

OIV-MA-AS323-01B consists, after mineralization, using sulfuric and nitric acids, in reducing arsenic V to arsenic III by means of potassium iodide in hydrochloric acid and the arsenic is transformed into arsenic III hydride (H₃As) using sodium borohydride. The arsenic III hydride formed is carried by nitrogen gas and determined by flameless atomic absorption spectrophotometry at high temperature.



CONCLUSIONS AND RECOMMENDATIONS

At the Level of the OIV:

Based on the data available and summarized above, all the relevant OIV structures should evaluate or develop:

- the possibility to reduce the current OIV limit to a level as low as possible. This limit should be determined in the light of the results of the circular letter decided by SECUAL sent to the OIV Members
- the need to produce speciation data for grapes, vines products and different wine types in function of origin (soil, winemaking, processes) and ageing
- the arsenic speciation validated method need to be developed by SCMA
- the part of inorganic Arsenic in wines is still unknown and data on the proportion of inorganic arsenic in wine by types and origin
- The draft of Code of practices on alternatives and solutions to reduce identified Arsenic contaminations for vines, grapes and wine

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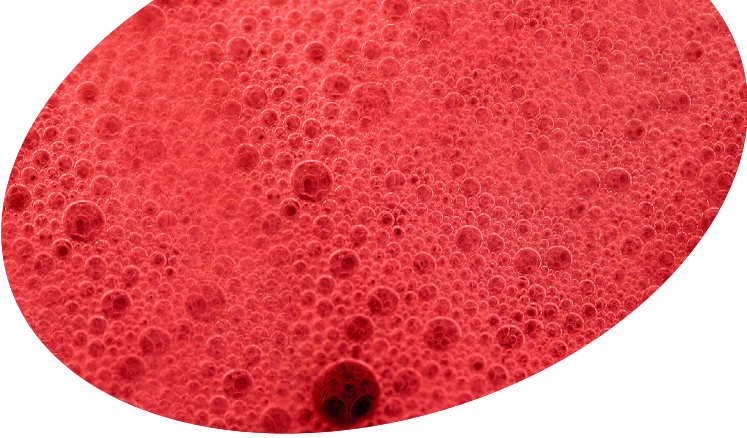
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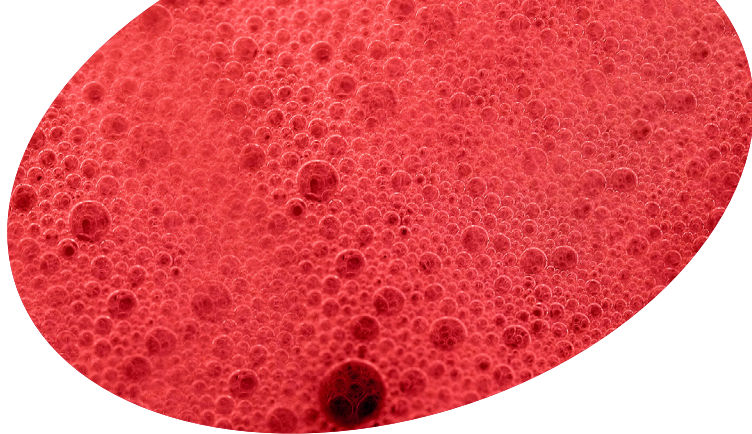
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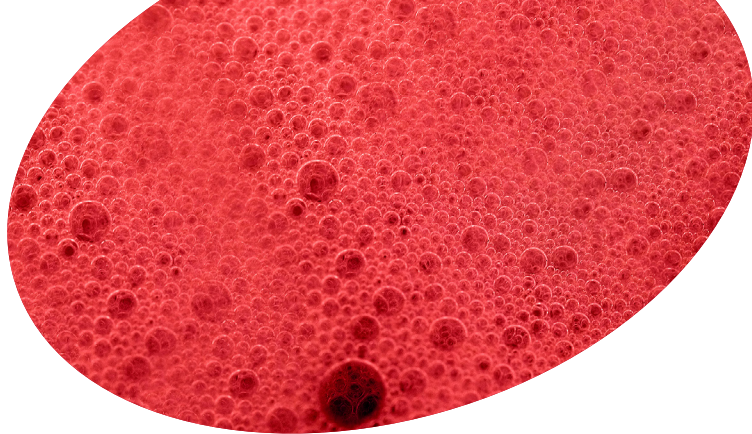
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Thanks, follow us.



International Organisation of Vine and Wine
Intergovernmental Organisation
Created on 29 November 1924 - Refounded on 3 April 2001

OIV