Arsenic in Wine: Where does it come from? What can I do to avoid contamination?

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Consumer organizations are increasingly concerned about the levels of heavy metals found in foodstuffs. Since many heavy metals are toxic in nature, there is a need for regulations to limit acceptable levels across the food and beverage industry.

Among other things, the issue of the presence of arsenic in wine was recently discussed in renowned famous US wine journals. (Ben O'Donnell, Wine Spectator 24. February 2016; Jennifer Langston University of Washington 29. September 2015; Brian Mastroianni, CBS News 01. October 2015)

Currently there is no official limit for arsenic in wine. Only the AIJN Code of Practice provides a limit of 50 µg/L for grape juice. According to the aforementioned journal, the authors ultimately concluded that there are wines with detectable arsenic levels, but wine cannot be blamed as the sole source of exposure to arsenic through food or drinks.

Total arsenic levels found in wine may have multiple contributing factors including the type of wine; vine growing practices; enological practices; and environmental contamination.

There is much debate among wine producers regarding methods for reducing arsenic levels in wine. The release of heavy metals into wine and fruit juice during processing is not a new challenge.

A study was conducted on arsenic levels in baby juice. In total 15 different juices were studied. In one case of clear apple juice, the arsenic content was found to be 24 µg/L. This high level of arsenic was believed to be a result of a correlation between the use of bentonite and Kieselguhr (diatomaceous earth=DE) during the production process of clear fruit juices.

In order to determine the contamination sources of heavy metals during the treatment of fruit juices, analytical screening of fining agents and filter aids was performed.

Screening samples of the most commonly used wine and fruit juice process fining agents and filter aids presented the following results for arsenic in Table 1 (C. Nissen 1998):

Table 1: Arsenic Content in Fining Agents and Filter Aids

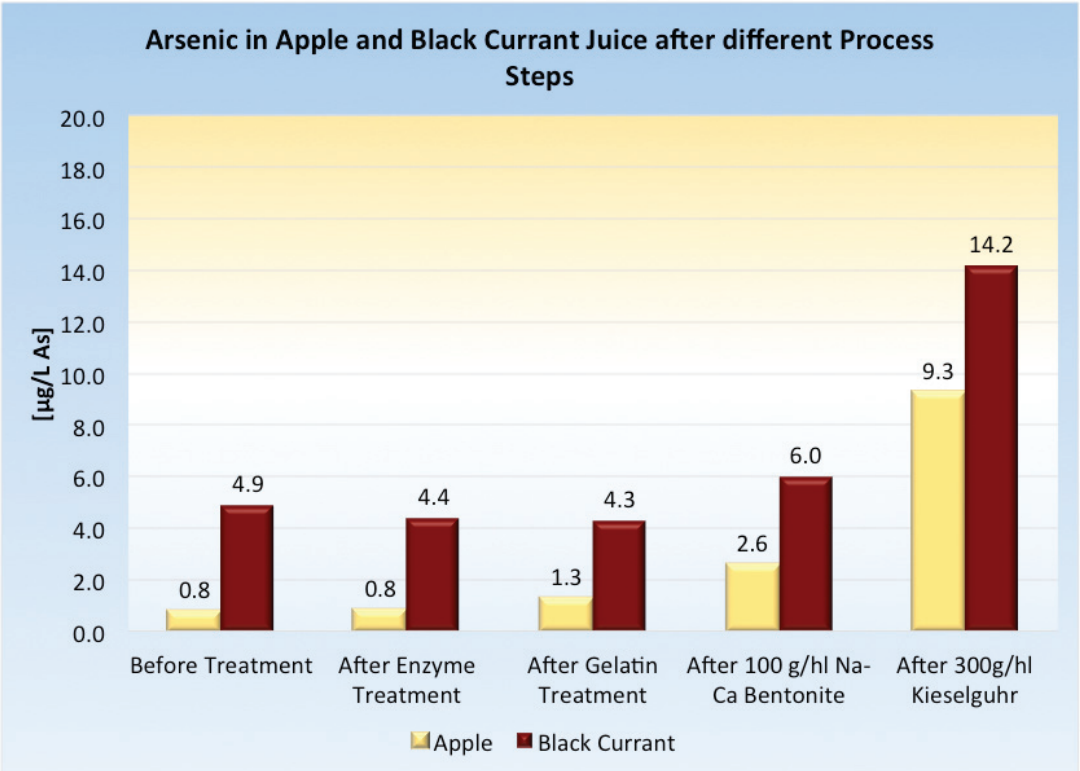
Sample Number	1	2	3	4	5	6	7	8	9	10
Enyzme [mg As/L]	0,72	0,06	0,34	0,08	0,04	-	-	-	-	-
Gelatine [mg As/L]	0,04	0,03	0,02	0,01	-	-	-	-	-	-
Bentonite Extract 1% Weinsäure [mg As/100g]	0,18	0,15	0,03	0,40	0,13	0,07	0,09	0,08	0,11	0,11
Calculated increase of Arsenic [µg/L], if 100 g Bentonite/100 L juice are used	1,8	1,5	0,3	4,0	1,3	0,8	0,9	0,8	1,1	1,1
Kieselgur extracted in KHP* Solution [mg As/kg]	0,68	1,04	2,00	2,96	1,80	3,64	3,48	2,52	-	-
Calculated increase of Arsenic [µg/L], if 300 g Kieselguhr/100 L Juice are used	2	3	6	9	5	11	10	8		
Perlite extracted in KHP Solution [mg As/kg]	1,08	0.34	0.31	-	-	-	-	-	-	-
Cellulose extracted in KHP Solution [mg As/kg]	0,02	0,02	-	-	-	-	-	-	-	-

*KHP= Potassium hydrogen phthalate

Considering the common quantities of the different fining agents that are typically used in the different process steps in wine and fruit juice production, it can be assumed that the arsenic level of the juice will increase when Bentonite, diatomaceous earth or perlite are used in the production process. Bentonite and Kieselguhr showed arsenic levels that could negatively impact the total levels of beverages treated with such substances.

To confirm the suspected contribution of processing aids as stated in Table 1: Enzyme No. 2, Gelatine No 5, Bentonite No 5 and Kieselguhr No. 6 were added in the production processes of apple and black currant juices on a lab scale basis.

The following graph depicts the evolution of arsenic content during the processing of both juices.



The Arsenic levels of both juices increased with the addition of Kieselguhr to the process. The addition of Bentonite resulted in a slight increase under the same given test conditions. Dosing quantity appears to be a key factor relative to the final release quantity. The obtained results confirm the findings of Enkelmann (1990) who reported possible increases in arsenic content after treatment with 300 g/100 liters Kieselguhr in a range of 3.7 to 14.3 µg/liters of wine.

Kieselguhr Precoat Filters and Depth Filter Sheets as a Possible Source of Arsenic Contamination in Wine Filtration

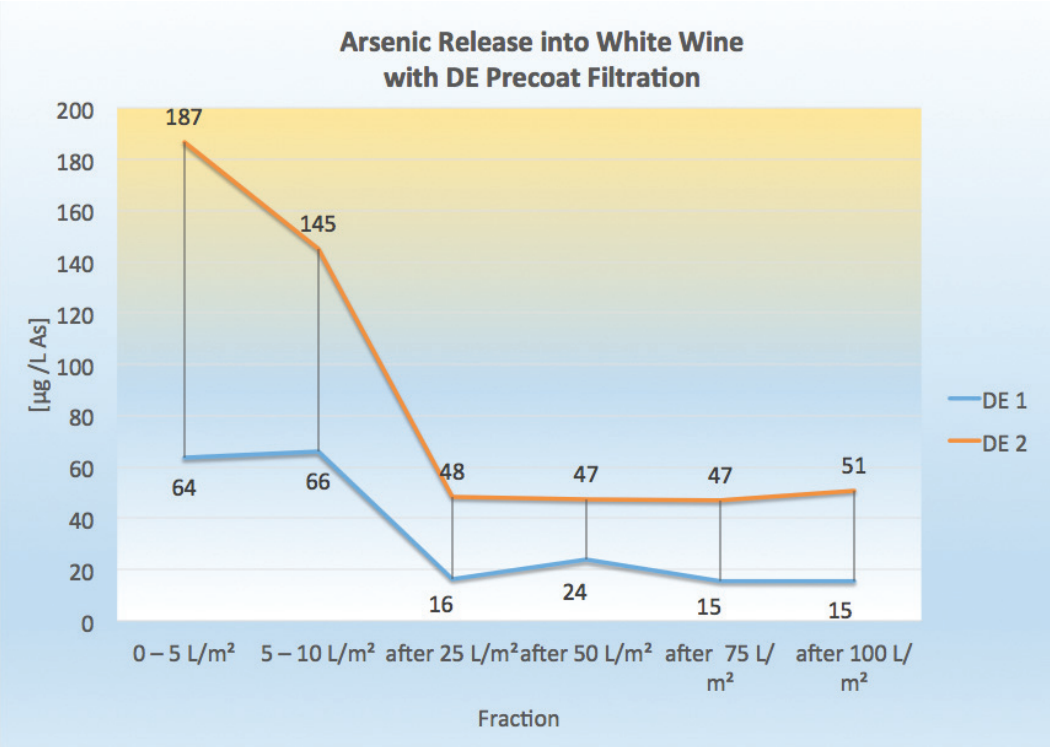
Kieselguhr is used in different types of precoat filters such as vacuum drum filters, candle filters, sieve filters or plate and frame filters.

In all of these precoat filter types, Kieselguhr is dosed into the product stream without any pre-rinsing or flushing step. Using Kieselguhr in this fashion has shown to release new arsenic ions into the product stream.

To test this theory, a precoat filtration step with 2 different Kieselguhr types was conducted on lab scale basis with white wine.

After pre coating with 1000 g/m^2 of Kieselguhr (a high quantity) the wine was filtered by constantly dosing 200 g/100 L into the wine.

This graph shows arsenic levels of wine during precoat filtration.



A release of very high levels of arsenic ions is detected when filtering through the precoated Kieselguhr cake. It can be assumed that the pure Kieselguhr used for the precoat that has not been water flushed is a major source for the release of arsenic into the wine. When Kieselguhr is continually dosed into the wine at the rate of 200 g/100 Liter, arsenic levels in wine are reduced to between 15 and 47 µg/Liter and remain unchanged for the duration of the filtration process. These values represent a significant increase in arsenic content of the filtered wine. To confirm these results from the lab scale test trials, additional large scale trials are required which should include a broader selection of different Kieselguhr types available on the market. Nevertheless, the lab scale test indicates a certain tendency towards the root cause of arsenic release during precoat filtration.

Analysis of a white wine which was filtered 3 times through a Kieselguhr precoat filter due to very bad filterability presented 90 µg/lAs, which supports the conclusion from the lab trial previously described.

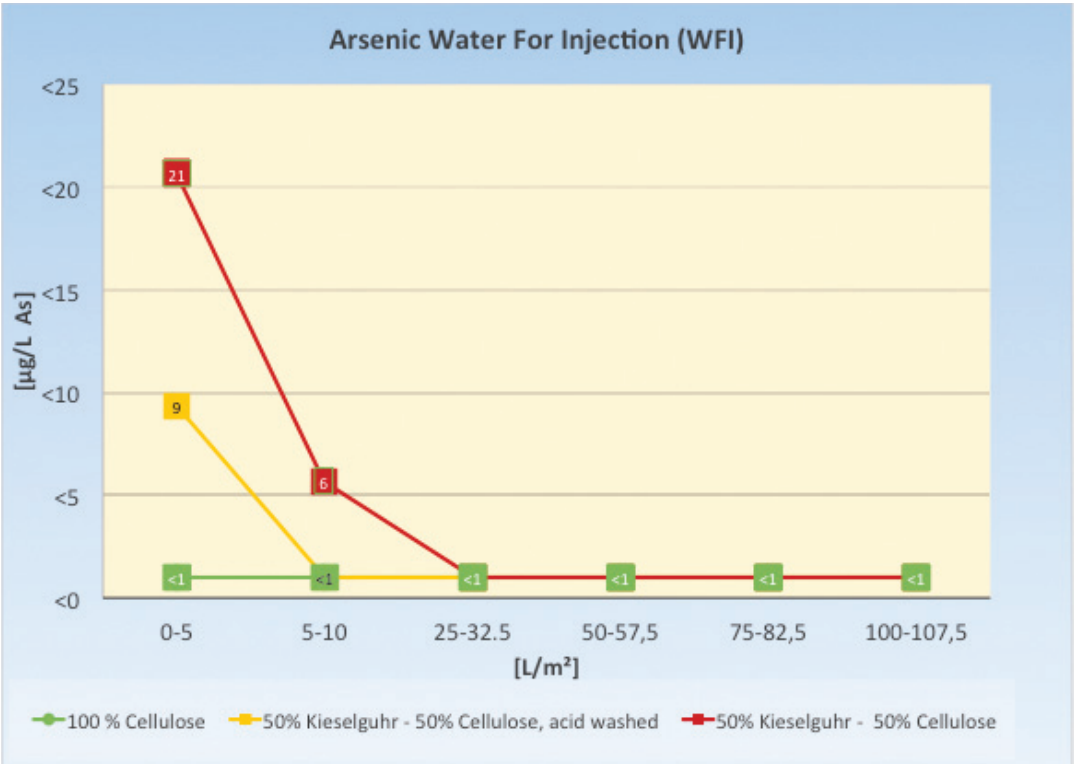
How are arsenic levels affected by using depth filter sheets containing Kieselguhr?

Very often depth filter sheets are used in beverage filtration. In most cases standard filter sheets with up to 50% Kieselguhr content are utilized in the production processes. For ion sensitive beverages such as distilled spirits, special acid washed, ion reduced sheets are available. Finally, 100 % pure cellulose sheets are available for beverage filtration applications.

How do depth filter sheets containing Kieselguhr behave in regards to arsenic release as compared to ion reduced and 100% cellulose based sheet types?

Standard sheets with 50 % Kieselguhr and 50% Cellulose; acid washed ion reduced sheet media with 50% Kieselguhr and 50% cCellulose and sheet media based on 100% pure cellulose media without Kieselguhr were tested for arsenic release when flushed with water. Three batches of each sheet type were flushed with water for injection in a 14 cm lab filter. Fractionated samples of the flushing water were taken to analyze the arsenic content during the course of the flushing process.

The following graph shows the progress of arsenic release when different types of depth filter sheets are flushed with water for injection:



When flushing filter sheets with water, it can be concluded that:

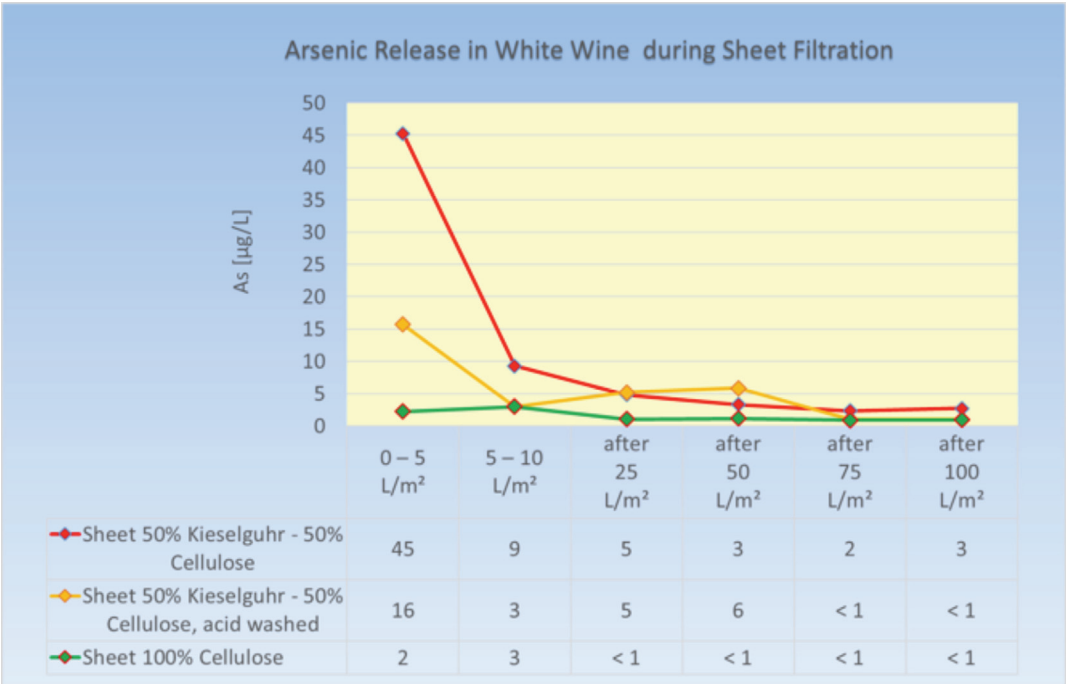
1. Standard Kieselguhr sheets (50% DE/50% Cellulose) present the highest initial release of arsenic ions.
2. Acid washed ion reduced sheets show lower initial release of arsenic ions (less than 50% as compared to standard Kieselguhr sheets.)
3. 100% pure cellulose sheets show no release of arsenic ions above the detection limit of 1 µg/Liter from the beginning of the flushing process.
4. The level of arsenic ions significantly decreases immediately following flushing a volume of about 10 Liters / m^2 filter area for both of the Kieselguhr sheets.

How are arsenic levels affected by the use of filter sheets in wine filtration?

A lab trial similar to the trial using water was performed to determine arsenic ion uptake during wine filtration.

In this test, standard sheet media with 50% Kieselguhr/50% Cellulose; acid washed ion reduced sheet media with 50% Kieselguhr / 50% cellulose and 100% pure cellulose media without Kieselguhr were tested for arsenic release in filtration.

The following graph shows the results of arsenic release when different types of depth filter sheets were used in wine filtration.



	0 – 5 L/m²	5 – 10 L/m²	after 25 L/m²	after 50 L/m²	after 75 L/m²	after 100 L/m²
Sheet 50% Kieselguhr - 50% Cellulose	45	9	5	3	2	3
Sheet 50% Kieselguhr - 50% Cellulose, acid washed	16	3	5	6	< 1	< 1
Sheet 100% Cellulose	2	3	< 1	< 1	< 1	< 1

When using depth filter sheets in wine filtration, it can be concluded that:

1. ***Pure cellulose sheets show no release of arsenic*** ions significantly above the detection limit of 1 µg/Liter from the beginning of the flushing process.
2. Arsenic release levels of both DE sheet types, standard sheets as well as acid washed sheets is significant at the beginning of the filtration process.
3. Standard Kieselguhr sheets show the highest initial release of arsenic ions into wine at the beginning of the filtration process.
4. Acid washed ion reduced sheets show lower initial release of arsenic ions (less than 50%) as compared to standard Kieselguhr sheets.
5. The level of arsenic ions significantly decreases immediately following flushing a volume of about 10 Liters / m² filter area for the Kieselguhr sheets.

Conclusion for the Winemaker: What can I do to prevent arsenic contaminations of wine in my production process?

Dust from the soil in the vineyards where the grapes are grown can be a source of arsenic levels in wine. Additionally, the wine making process itself is one of the most common sources of arsenic in wine. As a general rule, winemakers should strive to conduct the wine making process in a way that minimizes treatment of the wine. This is important for the dosing quantities of fining agents such as Bentonite.

Since Kieselguhr is believed to be one of the most prominent sources of arsenic in wine, the following recommendations are offered regarding the clarification filtration step:

1. Avoid using Kieselguhr precoat filtration in your process.
2. If your process allows flexibility in the filtration process, crossflow systems such as Pall's Oenoflow™ Microfiltration System is an alternative.
3. If crossflow filtration is not a feasible solution, consider using pure cellulose depth filter sheets such as Seitz®-ZD Filter Sheets which will eliminate the risk of arsenic contamination during sheet filtration.

4. If you are using depth filter sheets or lenticulars in your filtration process, then consider pure cellulose sheet media such as Seitz®-ZD Filter Sheets, SUPRAdisc™ II ZD Modules or SUPRApak™ ZD Modules.
5. Initiate filtration by using loop filtration back to the unfiltrate tank for about 5-10 minutes before the wine is processed.
6. If clarification requires use of depth filter sheets that contain Kieselguhr (*e.g.* for high colloidal removal) then rinse the filter sheets with water as recommended by the suppliers which will significantly reduce arsenic uptake.
7. To reduce high turbidity at the beginning of the wine making process and after fermentation, use a separator instead of Kieselguhr precoat filtration.
8. Use enzymes for pre-clarification to minimize the need for excessive filtration.

Literature

Ben O´Donnell, Wine Spectator 24.February 2016: “Should you worry about arsenic levels in Wine?” (http://www.cbsnews.com/news/red-wines-contain-high-arsenic-levels/)

Deb Belt; Annapolis Patch 18. February 2016: “Wines Named In Lawsuit Over Arsenic Levels: Whatever Happened?” (http://patch.com/maryland/annapolis/full-list-wines-named-lawsuit-over-high-arsenic-levels-0)

Jennifer Langston University of Washington 29.September 2015: “Arsenic found in many US red Wines, but Health Risks depend on total diet” (http://www.washington.edu/news/2015/09/29/arsenic-found-in-many-u-s-red-wines-but-health-risks-depend-on-total-diet/)

Brian Mastroianni, CBS News 01. October 2015:”Should you worry about arsenic levels in red wine? (http://www.cbsnews.com/news/red-wines-contain-high-arsenic-levels/)

R. Enkelmann 1990: Trace Element Release of Wine treatment products. 4. Notification: Kieselguhr; Deutsche Lebensmittel Rundschau 86(7); Page 314-321

C. Nissen 1998: Sources of Lead in Wine and Heavy Metals in Fruit Juice and Possibilities to avoid Contaminations, Geisenheimer Berichte, Volume 36,

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