A Process to Remove Mycotoxins from Green Coffee

G. BORTOLI, M. FABIAN

Demus S.p.A., via Caboto 31, 34147 Trieste, Italy; www.demus.it. E-mail: info@demus.it

SUMMARY

Mycotoxin contamination in a lot of green coffee, especially by ochratoxin A (OTA), over the limit allowed by Italian law (Circ. Italian Ministry of Health, n.18 of 16/11/2000, which fixes the limit at 8 ppb for green coffee), prevents its introduction into the home market, resulting in a possible relevant economic loss. The process here described allows OTA removal from the green coffee bean using a physical method as the extraction with a suited solvent, for instance dichloromethane. With this system OTA concentration lowers well below the maximum limit of 8 ppb, then recovering the toxin immodified in the extraction solvent and in by-products, without forming eventual degradation products.

OTA contamination is eliminated by the solvent contact with the green coffee bean, and at the end of the process all the solvent is turned away, obtaining a product with good organoleptic properties. If the process is realised in an acid environment, OTA removal is enhanced and caffeine extraction lowered, optimising the process.

RÉSUMÉ

La contamination d'un lot de café vert par des mycotoxines, en particulier l'ochratoxine A (OTA) au-dessus de la limite établie par la législation italienne (Circ. du Ministère de la Santé, n.8 du 16/11/2000 qui prévoit la limite maximale de 8 ppb pour le café vert), en interdit la circulation sur le marché national, ce qui risque d'entraîner da graves conséquences économiques. Le procédé décrit ici permet d'enlever l'OTA des graines de café vert en utilisant une méthode physique: l'extraction par un solvant approprié, dans ce cas spécifique le chlorure de méthylène. Grâce à cette méthode, on réduit la concentration de la toxine largement au-dessous de la limite maximale admissible, et en même temps on la retrouve inaltérée dans le solvant d'extraction et dans les sous-produits dérivés, écartant ainsi tout risque de formation d'éventuels produits de dégradation.

La contamination par OTA est éliminée par le contact avec le solvant et au terme du procédé on ne trouve pas de résidus de solvant, et ainsi on obtient un produit fini qui garde de bonnes caractéristiques organoleptiques. Le milieu acide favorise l'élimination des OTA alors qu'il ralentit l'extraction de caféine, en optimisant le procédé en question.

INTRODUCTION

Mycotoxin contamination in a lot of green coffee, especially by ochratoxin A (OTA), is an important problem because of the possible adverse effect on human health (Petracco, 1998).

Therefore several countries are imposing strict rules against the importation of contaminated lots into their home market.

THE PROBLEM

- Some countries have already set a limit. Among these is Italy, where the limit is of 8 ppb (ng/g) for green coffee and 4 ppb for roasted coffee (Italian Ministry of Health, 2000).
- Lots presenting a contamination above this level must be rejected at the border, resulting in a relevant economic loss.
- European Commission has so far considered limits for the importation of contaminated coffee lots as unnecessary, nevertheless a final decision will be taken by December 2002 (Document SANCO/0453/00).
- The efforts carried out for prevention, both on cultivation of coffee plant and on crop processing, should produce a reduction of the risk caused by OTA; nevertheless, the existence of contaminated lots inside the coffee market is still a serious problem.

THE SOLUTION

- Highly desirable appears therefore a process apt to reduce any level of OTA contamination below detectability, or to extremely low concentration: this will allow suitable for safe human consumption lots otherwise rejectable.
- The use of chemicals, as for instance hydrogen peroxide and ammonium hydroxide, is not ideal for detoxification because they react with OTA to decompose its molecules, so leading to degradation products of unknown toxicity.
- In our process, a solvent extracts OTA without changing its chemical structure. Pilot plant tests showed OTA unmodified in process by-products. Laboratory tests showed OTA removal up to 100%.

DESCRIPTION OF THE PROCESS

The process is based on the physical extraction of OTA, as such, from the green coffee bean using a suited solvent, chosen by its particular affinity for OTA. This method acts not only on the outer layer, but also inside the green coffee bean.

The process, as developed and patented (Fabian, 1997), comprises the following stages:

- Introducing a load of OTA contaminated green coffee into a container in which the coffee is subjected to continuous mixing at convenient temperature conditions.
- Introducing wet steam into the container and upkeeping it for the time required to make the green coffee beans porous and permeable.
- Introducing the solvent suited to remove OTA, and drive it away immediately after it has removed the entire amount of OTA.
- Eliminating all traces of the solvent from green coffee and recovering it by distillation. After separating from the solvent all OTA content, which concentrates in the residues, return the clean solvent into the process.

EXPERIMENTAL

We analysed 127 samples of green coffee, most belonging to Robusta species. Each sample, taken according to the ISO sampling method (ISO 4072-1982 (E), 1982), was completely ground, homogenised and submitted to extraction, immunoaffinity clean-up and HPLC-spectrofluorimetry analysis as described by Studer-Rohr et al. (1995).

We found 85 samples positive, above detection limit of 0.2 ppb. Most of them presented a concentration below the limit of 8 ppb, but we evidenced several samples with a higher contamination, with two outliers over 30 ppb as can be seen in Figure 1.

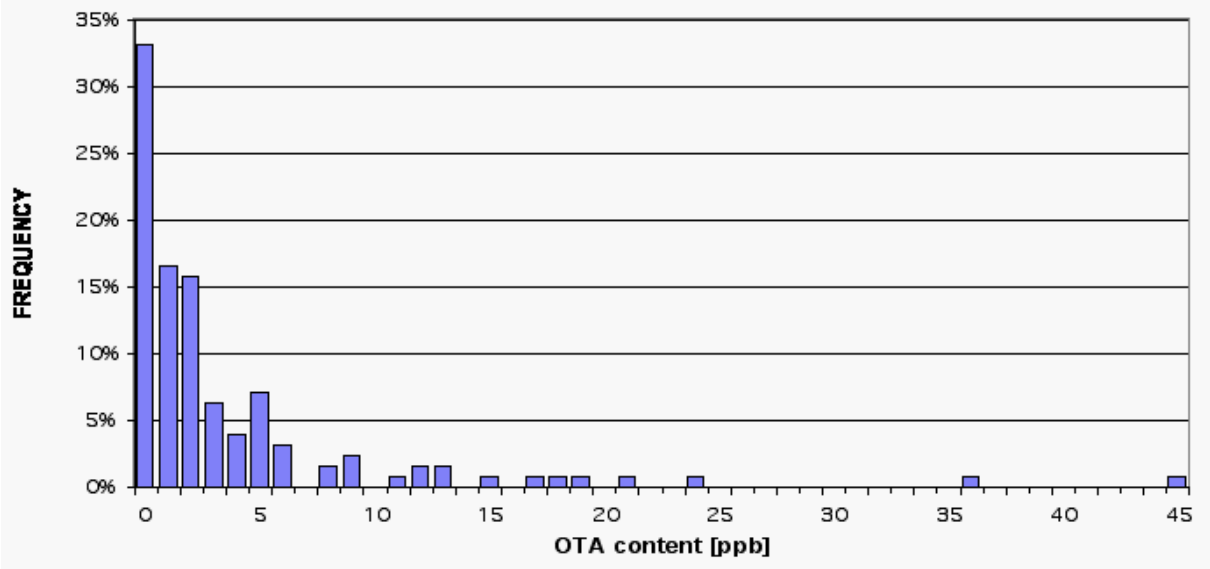

Figure 1. Contamination distribution of 127 analysed samples (85 positives)

Figure 2 shows OTA contamination of the 85 samples positive before our process, together with the OTA reduction percentage after the treatment.

For high OTA contamination the reduction has always been over 80%. The few cases of low reduction regard only samples with low OTA concentration, where sampling flaws may have affected the analysis

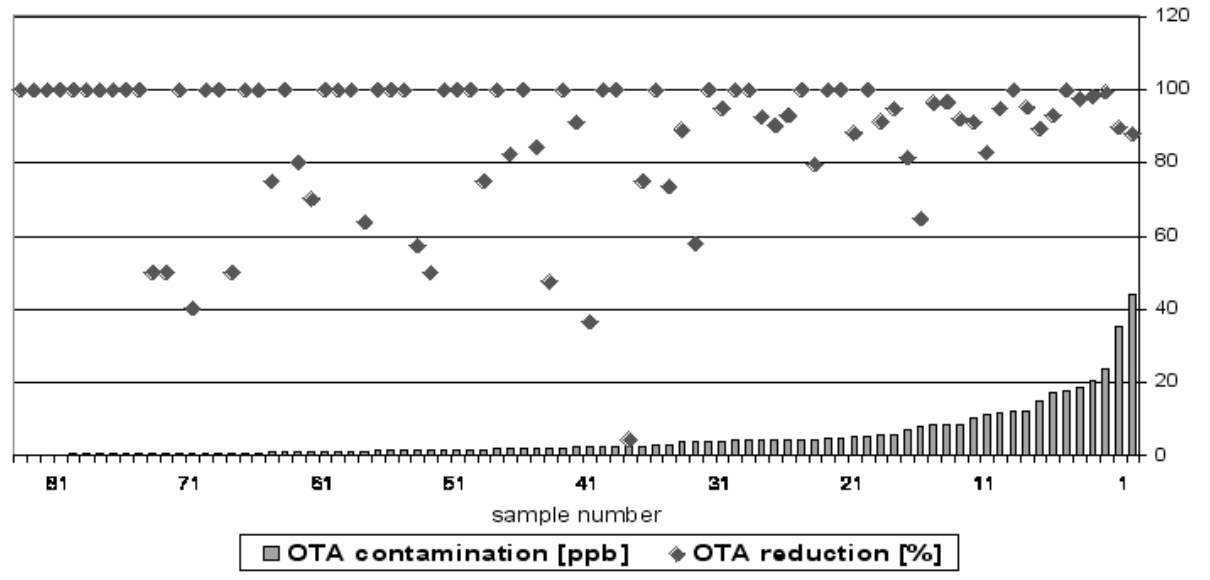

Figure 2. Contamination reduction in 85 positive raw coffee samples

IMPROVING THE PROCESS

At a laboratory scale, we made some tests to improve our process, with the purpose of minimising caffeine loss during the treatment while still extracting the whole OTA

amount.Best results were obtained using a solvent saturated with caffeine, or creating an acid environment.

Table 1 shows the results obtained treating a green Robusta coffee sample in a detoxification reactor. The extraction solvent utilised is a solution of formic acid in methylene chloride. For every test we repeated the process three times, reporting the average results.

Caffeine removal resulted modest, average of 27%. OTA reduction presented always high values, average of 80%. Further improvements are under study.

Table 1. Laboratory tests on 3 differently contaminated coffees, three-steps extractions with methylene chloride-formic acid 2%

		Caffeine				Ochratoxine A			
		in	out	removal	St.Dev.	in	out	removal	St.Dev.
Test	Iteration	[g/100g]	[g/100g]	[%]		[ppb]	[ppb]	[%]	
A	1	2,0	1,1	44		21,3	3,1	85	
	2	2,0	1,9	7		23,2	2,1	91	
	3	2,0	1,9	8		18,2	1,2	93	
	mean	**2,0**	**1,6**	**20**	21	**20,9**	**2,1**	**90**	4
B	1	2,9	1,9	34		15,3	1,7	89	
	2	2,3	1,8	19		13,2	1,4	89	
	3	2,3	2,0	12		11,9	0,9	92	
	mean	**2,5**	**1,9**	**22**	11	**13,5**	**1,3**	**90**	2
C	1	2,3	1,5	35		2,7	0,9	67	
	2	2,5	1,4	44		3,2	1,3	59	
	3	2,4	1,4	40		3,0	1,5	50	
	mean	**2,4**	**1,4**	**40**	4	**3,0**	**1,2**	**59**	8
3 LAB TESTS' AVERAGE:		**2,3**	**1,7**	**27**	16	**12,4**	**1,6**	**80**	16

ADVANTAGES OF THE TREATMENT

Utilising a proper solvent, for instance methylene chloride, shows the following advantages:

- It removes OTA selectively from the green coffee bean without interacting with aroma precursors of the product.
- No chemical reactions with the toxin occur, thus hindering the formation of potentially more toxic metabolites.
- Easy to drive away from green coffee after process, thanks to its low boiling point (39°C).

CONCLUSIONS

- With our process we can remove OTA from highly contaminated lots of green coffee, with a reduction above 80%.
- The coffee processed this way maintains its organoleptic properties without modifying cup quality.
- Caffeine content can be maintained at levels near to an unprocessed coffee.
- The bulk of OTA is recovered as such in the waxy by-products, to be disposed for non food/non feed utilisation.

- OTA-free processed coffee could be a way to eliminate the worry of up to 7% of global coffee production being prone to rejection, and eventually destruction, with great benefit for the least developed coffee producing countries' economy.

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