Quality Control System for Coffee with respect to Occurrence of Ochratoxin A in the coffee chain

1. Introduction

The EU has set regulatory limits for the occurrence of Ochratoxin A (OTA) in following foods: cereals (5 ppb), products derived from cereals (3 ppb), dried vine fruit (currants, raisins and sultanas all 10 ppb), roasted coffee (5 ppb), soluble coffee (10 ppb), wine and grape juice (both 2 ppb).

The limits for roasted and soluble coffee (and wine and grape juice) entered into force on 1st April 2005.[1]

The limits on roasted and on soluble coffee apply to the dry product. How these limits relate to maximum concentrations in the cup depends of course very much on brewing strength and also on the extraction efficiency (the latter mostly being high). Brewing strengths are quite variable between different countries across Europe. However, for a 40g/l brewing strength in combination with complete OTA extraction, the 5 ppb limit results in a maximum concentration in that cup of 0.2 µg/l (0.2 ppb). This means in effect that the limits for coffee are far stricter than those for the other regulated beverages.

This dossier describes a system for quality control to keep the products roasted coffee and soluble coffee below the regulatory limits mentioned above, including the arguments on which the system is built.

2. Considerations for setting up of the Quality control system

2.1 Health Risks

Several official scientific bodies evaluated the toxicity of OTA. This resulted in the setting of so called "tolerable intakes". JECFA, the Joint Expert Committee of WHO and FAO set the Provisional Tolerable Weekly Intake (PTWI) at 100 ng/kg bodyweight per week. The EU Scientific Committee on Food, the predecessor of the current European Food Safety Authority EFSA, set the tolerable intake at 5 ng/kg bodyweight per day, which is about 3x stricter than JECFA's PTWI.

At current OTA levels in coffee, consumption of the beverage made from 20 g coffee (~ 3 cups) contributes on average ~ 1% of the JECFA PTWI and ~ 3% of the more strict tolerable intake set by SCF.

The Dutch National Institute for Public Health and the Environment RIVM concluded in its *Risk Assessment of Ochratoxin A in the Netherlands* that "From the results summarized here, cereals were found to be the main contributors (55%) to the total Ochratoxin A intake. Since the 99th percentile of the life-long-averaged intake (28 ng / kg bw / week) is considerably lower than the provisional tolerable weekly intake (100 ng / kg bw / week), the current dietary intake of ochratoxin A in the Netherlands is concluded to pose no health risk".[2]
Similar conclusions were drawn in DG SANCO's *Assessment of dietary intake of Ochratoxin A by the population of EU Member States*: "Cereals are the main contributors (44%) followed by others (15%), wine (10%), coffee (9%), beer (7%), …."[3].
In the German study *Ochratoxin–A-Gehalt in Serumproben der deutschen Bevölkerung* it is stated that "Eine akute Gefährdung der Bevölkerung in Deutschland ist nicht erkennbar" (An acute risk for the population in Germany is not recognizable).[4]

2.2 OTA quality control

With the enforcement of OTA limits on roasted and on soluble coffee, a system for quality control is necessary to ensure that coffee complies with these regulatory limits. In the remainder of this dossier this will be elaborated.

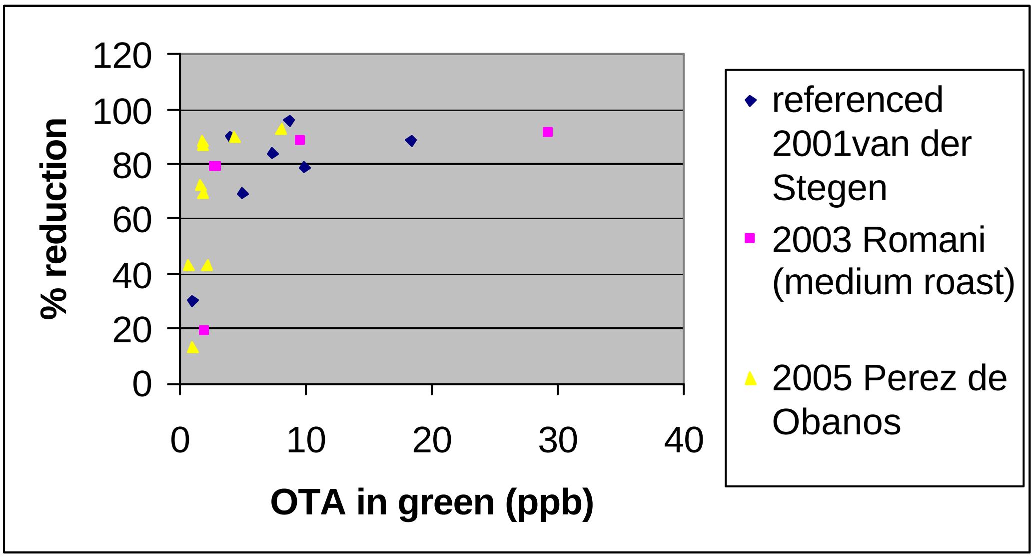
2.3 Prevention

The best method for quality control is prevention. The combined European coffee industry not only initiated, but also substantially contributed, both financially and by active involvement of its experts, to the global mould prevention project, which was executed in the coffee producing countries from 1999 to 2005 by the UN Food and Agricultural Organisation FAO under the auspices of the International Coffee Organization (see www.ico.org under 'activities' or the dedicated FAO-site www.coffee-ota.org).

2.4 Conversion factors

The different limits set for roasted coffee and for soluble coffee recognize the existence of a conversion factor between the two products. Similarly, the quality control system should recognize conversion factors in other / earlier process steps.

At this moment there are 11 published studies about the effects of roasting on OTA in the coffee. Nine out of these 11 studies report a very major or even almost complete reduction of OTA during roasting. For green coffees with over 4 ppb of OTA they report a reduction during roasting by a factor 3 up to a factor 10 down from the original level in the green. At lower starting levels in the green the reported reductions during roasting are more variable.



Graph 1: Reduction of OTA during coffee roasting

The two studies with deviating results applied heating conditions that differ substantially from the usual conditions of actual coffee roasting. In one case the heating was done with an "air heater" in metal scales, only reaching temperatures well below those in actual coffee roasting.[5]

Calculating with a reduction factor 3 is a conservative approach, considering the greater importance of the observed high reduction at higher contamination levels over the more variable reduction at low reduction levels.

2.5 Sampling and accuracy of analytical results

International transport of green coffee is currently mainly done in sea-containers, each containing about 20 tons of green coffee. Sampling of such containers "… at various places throughout the lot …" is in most cases physically not feasible. In addition, holding containers loaded with green coffee while waiting for the analytical result is in itself a risk: condensation of moisture and water dripping onto the coffee may cause mould growth, particularly in colder climates.

The inhomogeneity of mould growth and OTA contamination as well as the very low levels (parts per billion range) make the checking of green coffee for OTA inevitably a laborious exercise with very considerable inaccuracy.

In recent FAPAS exercises (2003) using homogenized roasted coffee, the group of 55 participating laboratories produced a coefficient of variation of 52%. After eliminating the ten labs with the most deviating results, the remaining coefficient of variation was still 25%.

The recent CEN report (CEN/TC275 N0125) reports for the step of grinding green coffee a coefficient of variation of ~15%.

For the green coffee sampling itself, we are not aware of any reports on accuracy. On the basis of analyses of several individual ("one take") samples out of one lot, a coefficient of ~ 40% can be estimated for a 'mycotoxin-type' sampling-step of green coffee.[6]

The combination of all these variables in the different steps lead to the conclusion that the complete procedure from sampling of the green coffee until OTA-analytical result will show a coefficient of variation of at least 50%.

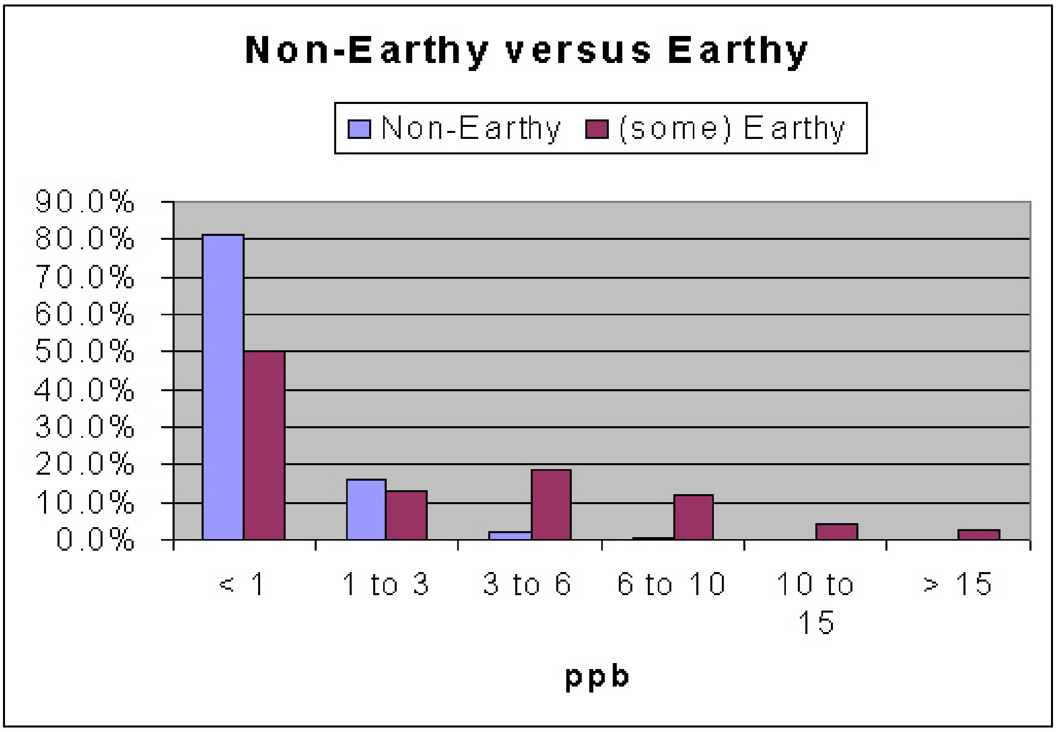
The most widely used analytical procedures for OTA in roasted and in soluble coffee are:
- Pittet et al. 1996.[7]
- CEN standard EN 14132.[8]

3. Risk factors for OTA contamination

In 1998 several European roasters co-operated to analyse a large number of different green coffee lots for currently practiced quality characteristics as well as for OTA. The aim was to examine whether one or more of these standard characteristics showed an increased risk for the presence of OTA contamination. A series of characteristics were checked, including the following ones: type of coffee, type of transport, moisture content at arrival, visual appearance / damages, mouldy / earthy off-flavour and OTA content.

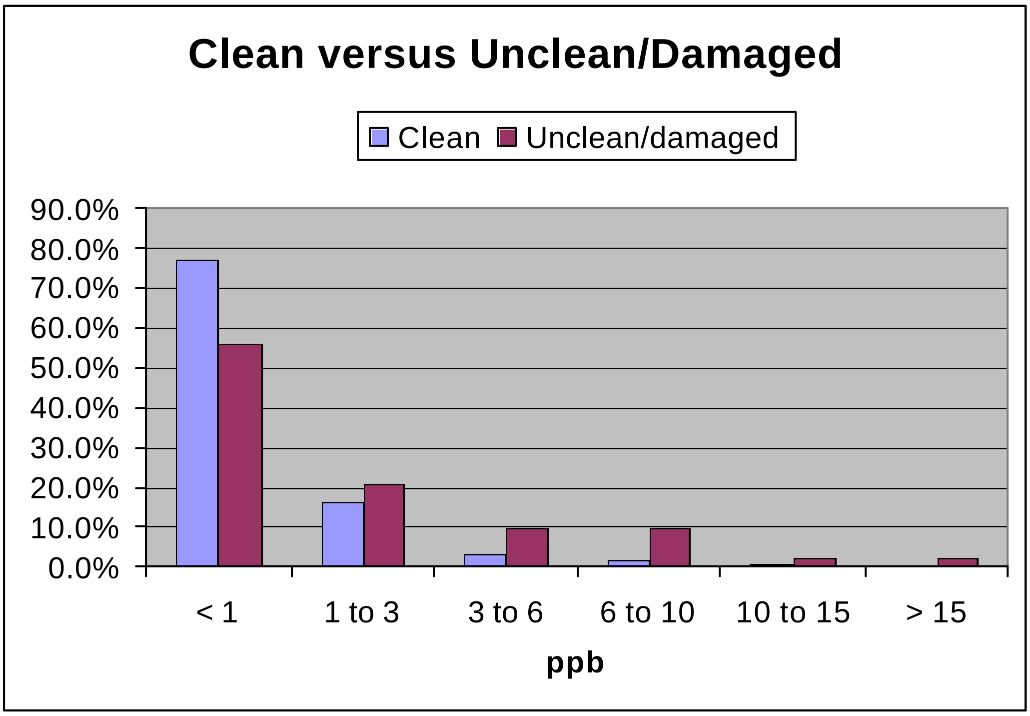
Moisture content upon arrival appeared not to present a clear indication for any OTA contamination. Although moisture management during the whole coffee production chain is crucial to reduce the risk of mould growth and OTA contamination, the moisture content upon arrival only shows a snap-shot picture and not the moisture history of the concerned lot.

In total 537 lots of green coffee were examined and 523 results on mouldy / earthy and 470 on visual appearance (unclean / damaged) were obtained. The frequency distributions of these lots over the different ranges of OTA contamination is show n in the graphs and table below.



Graph 2: OTA Contamination and Smell (Non-Earthy versus (some) Earthy)

The graphs and table clearly show that for the lots with the characteristics "non-earthy" or "visually clean", the risk for having an OTA contamination larger than 15 ppb is marginal. For both characteristics the risk in this sample collection is only 0.2%. This is obviously a very low risk. Therefore, the characteristics "non-earthy / earthy" smell and "clean / damaged" provide good checking parameters for quality control with respect to OTA contamination.



Graph3: OTA Contamination and Visual Inspection (Clean versus Unclean/Damaged)

	Non-Earthy	(some) Earthy	Visually Clean	Visually Unclean / Damaged
< 1 ppb	81,2 %	50,0	77,3	55,8
1 – 3	15,9	13,2	16,4	20,9
3 – 6	2,0	18,4	3,5	9,3
6 – 10	0,4	11,8	1,9	9,3
10 – 15	0,2	3,9	0,7	2,3
> 15	0,2	2,6	0,2	2,3

Table 1: OTA contamination and the defects earthy/mouldy and unclean/damaged

Besides this investigation by the co-operating European coffee-industry, a study in Thailand found that in dried coffee cherries with OTA contamination, 80% of the OTA was present in the dried flesh of the cherry, the so called "husk". [9]

A similar observation was made for an African coffee in the lab of the author of the dossier.

Consequently, these observations mean that incomplete separation of beans and husks, or the presence of beans in cherry in a lot of green coffee, indicate an increased risk of that lot being contaminated with OTA.

The above results and observations can serve as the basis to design a quality control system to ensure adequately low OTA levels in roasted and in soluble coffee.

The general outline of such a system are already described in the June 2004 issue of the Tea & Coffee Trade Journal.[10]

4. Quality Control System for Coffee with respect to OTA contamination

Based on its experience with coffee quality in general and in using the learnings of the FAO/ICO/CFC Mould Prevention project, the co-operating European coffee industry drafted a Code of Practice "Enhancement of Coffee Quality through Prevention of Mould Formation" This Code of Practice was adopted by the European Coffee Federation in June 2002 and is a supporting document for the implementation of the European Standard Coffee Contracts. It can be downloaded from www.ecf-coffee.org under 'publications')

Additionally a concise set of recommendations for prevention was distributed in the coffee production chain under the logo's of the International Coffee Organisation (ICO) UN-Food and Agricultural Organisation (FAO) and the co-operating European coffee sector.[11] These recommendations present practical measures for preventing OTA contamination along the coffee production chain. Since then, the learnings of the FAO global mould prevention project have resulted in more detailed and in-depth recommendations and procedures (www.coffee-ota.org)

Quality control in the consuming countries can be built on four levels, three of which can be seen as actual control levels:

- Selection at buying:

Either refrain from buying any lots which have to be qualified as OTA-suspect (by reason of their characteristics "earthy off-flavour", "visually damaged" or presence of beans in cherry), or buy and further process such lots only under strict OTA checking.

Procedures to do so can use the standard sensorial techniques as well as defect counting according to ISO 10470 (Green coffee - Defect reference chart).[12]

- Monitoring of supply and suppliers:

Goal of such monitoring is to develop and maintain a picture of the OTA-quality levels of different producers and suppliers and identify any changes.

For such objective a random sampling of the market supply is required. However, a focus can be put on those origins that have previously shown an increased OTA risk. The intensity of this monitoring for this purpose can be adapted to the types of coffee under concern.

- Checking at arrival of the lot:

The objective of this check is to identify lots that either deviate from the specifications based on the sample offered for sale, or that suffered damage/OTA contamination during transport. For this purpose, the arriving lots have to be checked before further processing for their characteristics “earthy off-flavour”, “visually damaged” and for the presence of beans in cherry. Suitable techniques for this checking are the standard sensorial techniques and defect counting according to ISO 10470 (Green coffee - Defect reference chart).

Lots that – based on these checks - have to be labelled as “OTA-suspect”, should be sampled and analysed for OTA before further processing. If the OTA level is below an acceptable level (taking into account the conversion factors mentioned in paragraph 2.4), the lot can be processed. If the OTA level of the lot exceeds the acceptable level, the lot can be sent through a cleaning procedure and once more checked for OTA.

- <u>Validation of the quality control system:</u>

The objective of this check is to validate the quality control system itself. By regular sampling and analysing the end product it has to be validated that the system is able to keep the products roasted coffee or soluble coffee within the respective regulatory limits. If OTA levels in the final products approach the limits, feedback and stricter criteria at buying and/or at checking upon arrival and/or storage of lots have to be applied to correct the level. It is a system with feedback and dynamic control.

The combined effects of the FAO/ICO.CFC Mould Prevention project as well as the other efforts and measures taken by the coffee sector have led to a steady decrease of the mean OTA levels in roasted coffee on the European market since 1995. In that period the mean OTA level in roasted coffee decreased from 0.81 ppb, via 0.62 ppb in 1999 (SCOOP report) to 0.55 ppb in 2001. This constitutes a monitoring/validation of the measures taken by the coffee sector as a whole. Each individual processor/roaster has to validate the quality control system of its own processing to demonstrate that its system is effective in keeping levels in its products below the regulatory limits.

	Number of Samples	1995 (mainly ISIC)	1996-2000 (mainly SCOOP)	2001 (mainly ISIC)
6 countries sampled 3 times (B, Dk F, Dld, It, NL)	1188	0.90 ppb	0.69 ppb	0.51 ppb
9 countries, sampled once or twice (A,SF, Gr, Irl, P, Sp, Sw, UK, CH)	376	0.48 ppb	0.61 ppb	0.66 ppb
All countries	1564	0.80 ppb	0.63 ppb	0.55 ppb

Table 2: Trends in mean OTA levels in roasted coffee in Europe

5. Conclusions and Recommendations

- The Dutch National Institute for Public Health and the Environment RIVM concluded that OTA is not a direct health risk for the Dutch population. Similar conclusions were drawn in other countries. Therefore OTA formally does not have to be a CCP in the HACCP-system. Nevertheless, a quality control system is needed to make sure that OTA levels in roasted coffee and soluble coffee are kept within the regulatory limits.

- Effective quality control for OTA can be implemented on the basis of standard quality characteristics, like an “earthy off-flavour”, “visually damaged” or presence of “beans in cherry”. This is based on the results of analyses of large numbers of coffee samples.
- Such quality control system contains selection at buying, monitoring of market supply / suppliers, checking upon arrival plus validation of effectiveness of the control system.
- This quality control system is a dynamic system which – through the feed-back of results from monitoring of supply and of final products – ensures that the levels in roasted and in soluble coffee are being kept below the regulatory limits of 5 respectively 10 ppb.

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GvdS / European Coffee Co-operation Task Force
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References

1. EU Regulation 123/2005 of 26 January 2005, Official Journal L25/3 28/1/2005 (see appendix)

2. RIVM report 388802025/2002, Risk Assessment of Ochratoxin A in the Netherlands

3. DG SANCO's Report on tasks for scientific cooperation; Report of experts participating in Task 3.2.7, January 2002, Assessment of dietary intake of Ochratoxin A by the population of EU Member States.

4. Ochratoxin-A-Gehalt in Serumproben der deutschen Bevolkerung, by H. Rosner *et al.* in Infektionsepidemiologische Forschung (II /1998); 11-12

5. Effect of roasting conditions on reduction of OTA in coffee, by G. van der Stegen, *et al.* in J.Agric. Food Chem. (2001); **49**, 4713-15 *(and references cited there in)*

    a. Influence of roasting levels on Ochratoxin A content in coffee, by Santina Romani *et al.* in J.Agric. Food Chem. (2003); **51**, 5168-5171

    b. Influence of roasting and brew preparation on the ochratoxin A content in coffee infusion, by A. Perez de Obanos *et al.* in Fd. Add. Cont. (2005); **22**(5), 463-471

6. The occurrence of Ochratoxin A in coffee, by I. Studer-Rohr *et al.* in Fd.Chem.Toxic. (1995); **33**(5) 341-355

7. Liquid chromatographic determination of OTA in pure and adulterated soluble coffee using an immunoaffinity column cleanup procedure, by Pittet *et al.* in J.Agric. Food Chem. (1996); **44**, 3564-3569

8. CEN standard EN 14132: Determination of Ochratoxin A in barley and roasted coffee - HPLC method with immunoaffinity column clean-up. This method has been validated for Ochratoxin A contents in barley in the range from 0,1 µg/kg up to 4,5 µg/kg and for roasted coffee in the range from 0,2 µg/kg up to 5,5 µ/kg. Can be ordered from one of the member organisation of the European Committee for Standardization; see www.cenorm.be.

9. Development of Ochratoxin A during Robusta (*Coffea canephora*) coffee cherry drying, by Bücheli *et al.* in J.Agric.Food Chem. (2000); **48**, 1358-1362

10. Way of Dealing with molds & Ochratoxin A in Coffee, by G. van der Stegen in Tea &Coffee Trade Journal, June 2004, pp 30-35 (see appendix)

11. FAO/ICO/Taskforce leaflet 'Improve your coffee quality by prevention of mould growth' (see appendix)

12. ISO 10470 Green coffee - Defect reference chart. Can be ordered directly from ISO through www.iso.org.

Appendices

- Commission Regulation 123/2005 of 26 January 2005
- Copy Tea & Coffee Trade Journal article
- ECF Code of Practice; this document includes as an annex ISO 6673-1983 Green coffee - Determination of loss in mass at 105 °C
- FAO/ICO/Taskforce leaflet 'Improve your coffee quality by prevention of mould growth'