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Occurrence of Cadmium in Cocoa and Coffee

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Introduction

Some years ago we published in this journal a study (1) about the mineralization of high fat content samples, in order to reach a complete destruction of the organic matrix, especially of the fat, and the precautions to be taken against different possible sources of contaminations, for a reliable electrothermal atomic absorption spectrometric (ET-AAS) metals determination.

Recently the wet digestion method with nitric acid under temperature and pressure in closed systems was adopted in Germany as official method of mineralization for the determination of lead and cadmium in foods (2). The mineralisation device that we use, the High Pressure Asher (HPA) represents a perfected, microprocessor controlled system, for the digestion according to this method. Meanwhile we mineralised a large number of raw materials and finished chocolate and confectionery products in which we analysed the cadmium, lead, cooper and zinc content.

For cocoa beans we found that the data published until now about copper and zinc (3–11) which are present in cocoas of different origins at levels of the same order of magnitude, 10–40 mg/kg for the copper and 35–65 mg/kg for the zinc, can be considered as significant.

The cadmium is present at much lower levels in cocoas but the content can vary from one origin to another by a factor up to one hundred (8–15). The current published data are insufficient for a good classification of the cocoas of different origins according to their cadmium content. For example, the Colombian cocoa could be considered as a cocoa with a medium level of cadmium, 0.3–0.6 mg/kg (14). We found for eight different Colombian cocoas contents between 3 and 6.5 mg Cd/kg. According to our data, this origin must be considered as having a rather high cadmium content, or maybe, in respect to the cadmium, there are two different cocoa qualities from this country. Taking into account the toxicity of cadmium and the need to have this parameter under control in the finished chocolate and confectionery products, a collaborative study coordinated by the Swiss Federal Office of Public Health is being carried out, and this article has no intention of anticipating or substituting this study.

Of course, to build a solid data bank is only a matter of time, but it is most interesting to find out what is at the origin of the differences in the cadmium content of different cocoas. Is it a genetic factor which predominates, allowing some cocoa

varieties to accumulate more cadmium than others, or is it a general characteristic of the cocoa plant and only the differences in the availability of the cadmium in the soil are determinant? This question has already been raised by other authors. *Knezevic* (11, 12) supposed that some cocoa varieties would have the capability to accumulate more cadmium from the soil. *Matissek* and *Burkhardt* (14) assumed that the availability of the cadmium in the soil together with a genetically determined, different capability of cadmium accumulation by the cocoa plant, will be at the origin of the higher cadmium content of the so called «noble» cocoa varieties. These authors excluded from the sources of cadmium in the soil so called «civilisation» influences as for example the fertilizers. Nevertheless in the fact sheet about heavy metals issued by the International Office of Cocoa, Chocolate and Sugar Confectionery (IOCCC) (16) the mentioned main sources of cadmium in food and the environment are: emissions from coal and oil-fired power stations, industrial processes and some sewage sludge used as fertilizer. Reviews about the cadmium contamination and toxicology (17–18) also mentioned the phosphate fertilizers as an important source of cadmium contamination in agricultural soils and the content of cadmium in these fertilizers is variable, depending on the geographical origin of the rock phosphate.

Unfortunately it is not easy to solve the problem of the origin of the differences in the cadmium content of cocoa, taking into account the need to have samples of genetically different cocoas and the corresponding soils from around the world. As known, the species Theobroma cacao is divided in two main groups, termed *«Criollo»* and *«Forastero»*, and a third group, known as *«Trinitario»* which is basically a cross between the two groups (19). We had the possibility to study cocoa beans from all these different varieties of cocoa coming from the same experimental research station, Bingerville in Ivory Coast. Our approach was that if the genetical differences with respect to the capability of cadmium accumulation are determinant, then differences in the cadmium content between the different varieties of cocoa grown on the same soil, should be observed.

Moreover, we analysed commercial coffee samples of different origins for cadmium content. Even if botanically the coffee plant belongs to the family *Rubiaceae* and cocoa to the family *Sterculiaceae*, they are cultivated in similar tropical areas. For us it was interesting to see whether similar large differences in the cadmium content of different coffees could be found. There is not much literature on this subject. In the monography of *Maier* (20), for the cadmium content in coffee it is mentioned: < 0.1 mg/kg. The same value < 0.1 mg/kg is given for 14 different coffee samples analysed by the Swiss official laboratory of the city of Basel in 1984 (21), and only for the East-African coffee sample the value of 0.03–0.05 mg/kg of cadmium was precised.

Experimental

The experimental conditions for the determination have been described in the previous article (1). For the sample preparation, only the temperature programme

of the HPA (Anton Paar K.G., Graz, Austria) was slightly modified. The actual programme we use for the mineralization of the cocoa nibs and the coffee beans is given in graphical form in the figure 1, which is very close to the image obtained for the temperature programme on the HPA microprocessor assembly screen.

The same atomic absorption spectrophotometer Perkin-Elmer, model 3030, was used but the system was updated with the new graphite oven HGA-600, and in place of hollow cathode lamps, electrodeless discharge lamps (EDL) have been used. All the precautions for avoiding contaminations were strictly maintained.

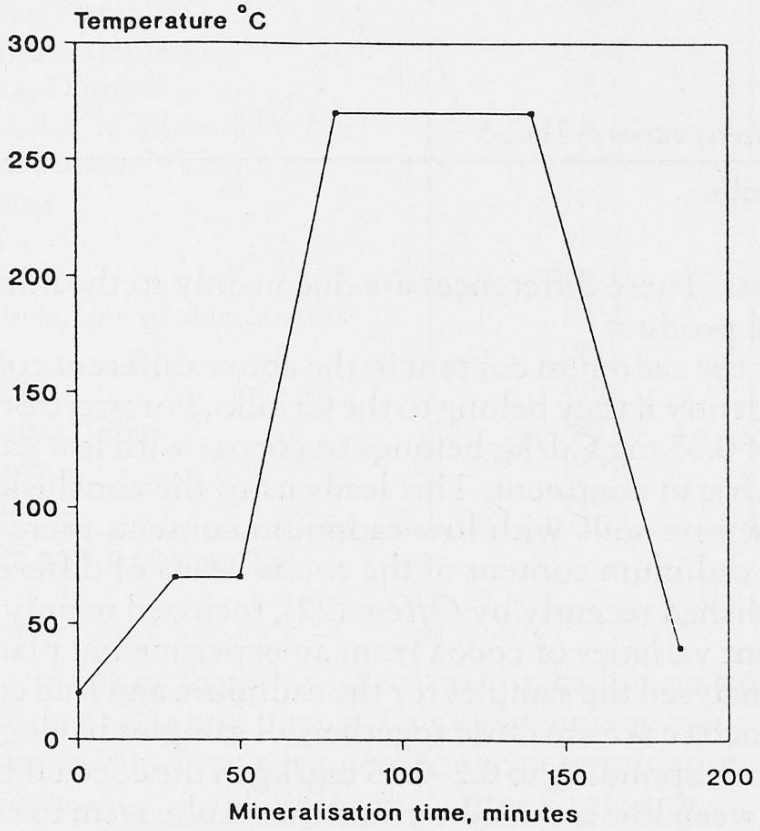

Fig. 1. Temperature programme for the mineralization of cocoa nibs and coffee beans in the High Pressure Asher

Results and discussion

The analysed cocoa bean samples and the obtained results for the cadmium content are given in table 1.

The shells of the cocoa beans have been removed and the nibs have been ground with a laboratory grinder. For each sample, 4 analyses have been performed with separate mineralizations and each mineralized solution was analysed twice. The differences of the individual values in respect to the mean given in the table are of

Table 1. Cadmium content of different varieties of cocoa beans* from Bingerville, Ivory Coast

Type of cocoa	Cd (mg/kg)
Criollo ICS 39	0.06
Criollo VF 667	0.04
Forastero Upper Amazon Pa 150	0.04
Forastero Upper Amazon Na 32	0.05
Forastero Upper Amazon T 59/501	0.04
Trinitario ICS 84	0.04
Trinitario WA 40	0.06
Trinitario GW 1	0.07
Amelonado (Forastero variety) IFC-5	0.04

* Results on the nibs

± 0.01 mg/kg or less. These differences are due mainly to the inhomogeneity of the samples as natural product.

The results for the cadmium content in the above different cocoas are very close together independently if they belong to the Criollo, Forastero or Trinitario variety. The mean value of 0.05 mg Cd/kg belongs to cocoas with low cadmium content as for most of the African continent. This leads us to the conclusion that at least for cocoa plants grown on soils with low cadmium content, there are practically no differences in the cadmium content of the cocoa beans of different varieties.

In a study published recently by *Offem* (22), focussed mainly on the amino acid content of different varieties of cocoa from an experimental plantation in Nigeria, the authors also analysed the samples for the cadmium and lead content. The results on dry defatted cocoa cake are close together, all samples having between 0.45 and 0.75 mg Cd/kg, corresponding to 0.2–0.33 mg/kg in the cocoa nibs. This level could be considered between low and medium and the results seem to confirm our former conclusion, if the external contamination sources by the transformation of the cocoa nibs in dry defatted cocoa cake have been avoided and no volatilisation losses of cadmium during the dry ashing occurred.

We are looking forward to other opportunities to analysing samples of different cocoa varieties grown in a South American region where cocoa with higher cadmium content comes from. This with the aim to verify if all the varieties are more or less at the same, higher level of this element. Analyses of the corresponding soils will bring us a supplementary confirmation.

As mentioned in the introduction, we analysed commercial coffee bean samples of different origins for cadmium content and the results are presented in table 2. The given values are the mean of 3 analyses performed with separate mineralizations and each mineralized solution was analysed twice. The differences of the individual values in respect to the mean have been of ± 0.005 mg/kg or less. The differences are due to the inhomogeneity of the samples as well as to the fact that the values are close to the lower limit of our method.

Table 2. Cadmium content of coffee samples*

Country and Type	Year	mg Cd/kg
Kenyan Arabica (sample 1)	1989	TR
Kenyan Arabica (sample 2)	1990	0.005
Kenyan Arabica (sample 3)	1990	TR
Kenyan Arabica (sample 4)	1990	0.005
Colombian Arabica (sample 1)	1989	0.006
Colombian Arabica (sample 2)	1990	0.016
Colombian Arabica (sample 3)	1990	0.006
Colombian Arabica (sample 4)	1990	0.006
Ethiopian Arabica, Djimma	1991	TR
Brazilian Arabica, Sul de Minas, NY-2	1991	TR
Brazilian Arabica, Santos, NY-2	1991	0.005
Paraguayan Arabica	1991	0.005
Bolivian Arabica	1991	TR
Honduran Arabica	1991	0.019
Guatemalan Arabica, low grown central	1991	0.008
Mexican Arabica	1991	TR
Equadorian Robusta	1991	0.007
Ivory Coast Robusta, Grade 2	1991	TR
Indonesian Robusta	1991	0.005
Madagascan Robusta	1991	TR

* TR = traces (0.002–0.004 mg/kg)

These results indicate that in respect to the cadmium content, there are no similarities between coffee and cocoa. This element is present in all the coffees we analysed, at the same very low level, near to the determination limit of our method and it did not represent a problem for the coffee comodity.

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Summary

Cocoa beans from different varieties of cocoa trees, grown on the same soil in Bingerville, Ivory Coast, have been analysed for cadmium content. No particular capability of any variety to accumulate cadmium was observed. All the samples contained between 0.04 and 0.07 mg

Cd/kg. These results support the supposition that the content of this element in the soil should be considered as determinant and probably responsible for the much higher cadmium level in some «noble» cocoas. Analyses on a number of 20 samples of *Arabica* as well as *Robusta* trade coffees, coming from 13 countries, demonstrate that the cadmium is present only at a very low level, under 0.02 mg/kg, and it did not represent a problem for this commodity.

Zusammenfassung

Kakaobohnen von Kakaobäumen verschiedener Arten, die auf demselben Boden in Bingerville, Elfenbeinküste, gewachsen sind, wurden auf den Cadmiumgehalt analysiert. Alle Muster enthielten zwischen 0,04 und 0,07 mg Cd/kg und somit wurde keine besondere Cadmiumspeicherfähigkeit beobachtet. Diese Resultate unterstützen die Annahme, dass der Cadmiumgehalt des Bodens der massgebende Faktor ist und für die viel höheren Cadmiumgehalte einiger «edlen» Kakaos verantwortlich ist. Die Analysen von 20 *Arabica* sowie *Robusta* Handelskaffeemustern aus 13 Ursprungsländern zeigten, dass im Kaffee nur sehr wenig Cadmium vorhanden ist, unter 0,02 mg/kg, und es somit kein Problem für dieses Genussmittel darstellt.

Résumé

Des fèves de cacao provenant de variétés différentes d'arbres de cacao cultivés sur le même sol à Bingerville, Côte d'Ivoire, ont été analysées pour le contenu en cadmium. Aucune capacité spéciale pour accumuler du cadmium n'a été observée, tous les échantillons contenant entre 0,04 et 0,07 mg Cd/kg. Ces résultats supportent l'hypothèse que le contenu en cadmium du sol doit être considéré comme déterminant et probablement responsable pour le niveau beaucoup plus élevé en cadmium de certains cacaos «nobles». Les analyses d'un nombre de 20 echantillons commerciaux de café, des *Arabica* ainsi que des *Robusta,* provenant de 13 pays d'origine différente, démontrent que le cadmium est présent seulement à un très bas niveau, en dessous de 0,02 mg/kg, et ne représente pas un problème pour cette denrée.

Literature

1. *Ciurea, I.C., Lipka, Y.F.* and *Humbert, B.E.:* Trace analysis of mineral elements in raw materials and finished products in the chocolate industry. I. Study of the mineralization of high fat content samples with HPA apparatus for the determination of lead and cadmium ultratrace content by electrothermal atomic absorption spectrometry. Mitt. Gebiete Lebensm. Hyg. **77,** 509–519 (1986).
2. Untersuchung von Lebensmitteln. Aufschlussverfahren zur Bestimmung von Blei und Cadmium in Lebensmitteln. Druckaufschluss. Amtl. Sammlung § 35 LMBG, L 00.00-19, 1–3, December 1989.
3. *Knezevic, G.:* Heavy metals in foodstuffs. The copper content of raw cocoa, intermediate- and finished cocoa products. CCB. **5** (2), 24–26 (1980).
4. *Knezevic, G.:* Schwermetalle in Lebensmitteln. Über den Kupfergehalt in Rohkakao, Kakao-Halb- und -Fertigprodukten. Zucker- Süssw. Wirtsch. **33,** 75–77 (1980).

5. *Knezevic, G.:* Schwermetalle in Lebensmitteln. Über den Zinkgehalt in Rohkakao, Kakao-Halb- und -Fertigprodukten. Zucker- Süssw. Wirtsch. **35,** 97–99 (1982).
6. *Knezevic, G.:* Heavy metals in foodstuffs. The zinc content of raw cocoa, intermediate- and finished cocoa products. CCB. **8** (2), 6–8 (1983).
7. *Olaofe, O., Oladeji, E.O.* and *Ayodeji O.I.:* Metal contents of some cocoa beans produced in Ondo State, Nigeria. J. Sci. Food Agric. **41,** 241–244 (1987).
8. *Knezevic, G.:* Über die Verteilung von Metallen in Kakaofrucht. Zucker- Süssw. Wirtsch. **36,** 179–180 (1983).
9. *Knezevic, G.:* Über den Metallgehalt in Kakaobohnen und -schalen. Zucker- Süssw. Wirtsch. **36,** 319–320 (1983).
10. *Lee, C.K.* and *Low, K.S.:* Determination of cadmium, lead, copper and arsenic in raw cocoa, semifinished and finished chocolate products. Pertanika **8,** 243–248 (1985).
11. *Knezevic, G.:* In Rohkakao und Kakao-Halb- und -Fertigprodukten keine Belastungen durch Spurenelemente. Zucker- Süssw. Wirtsch. **40,** 287–289 (1987).
12. *Knezevic, G.:* Schwermetalle in Lebensmitteln. 1. Mitteilung: Über den Gehalt an Cadmium in Rohkakao und in Kakao-Halb- und -Fertigprodukten. Dtsch. Lebensm.-Rundsch. **75,** 305–309 (1979).
13. *Prugarova, A.* and *Kovac, M.:* Lead and cadmium content in cocoa beans. Nahrung **31,** 635–636 (1987).
14. *Matissek, R.* and *Burkhardt, H.G.:* Schwermetallspuren in Kakao und Kakaoerzeugnissen. Gordian **89,** 157–162 (1989).
15. Kantonaler Vollzug der Lebensmittelgesetzgebung. Kakaoerzeugnisse – Produits au cacao. Mitt. Gebiete Lebensm. Hyg. **74,** 250–252 (1983).
16. IOCCC Fact Sheet – Heavy metals. International Office of Cocoa, Chocolate and Sugar Confectionery, Bruxelles, October 1989.
17. *Veron, C.:* Les mécanismes de contamination alimentaire par le cadmium principalement la chaîne trophique air-sol-végétaux-animaux-homme (1). Ann. Fals. Exp. Chim. **83,** No. 888, 201–224, 1990.
18. *Robards, K.* and *Worsfold, P.:* Cadmium: Toxicology and analysis. Analyst **116,** 549–568 (1991).
19. *Braudeau, J.:* Collection techniques agricoles et productions tropicales. In: *Coste, R.* (ed.), Le Cacaoyer, Vol. XVII, Chap. I. Ed. G.-P. Maisonneuve & Larose, Paris 1969.
20. *Maier, H.G.:* Grundlagen und Fortschritte der Lebensmitteluntersuchung und Lebensmitteltechnologie. In: *Kiermeier, F.* (ed.), Kaffee, Band 18, S. 34. Verlag Paul Parey, Berlin und Hamburg 1981.
21. Kantonaler Vollzug der Lebensmittelgesetzgebung. Kaffee – Café. Mitt. Gebiete Lebensm. Hyg. **75,** 314–315 (1984).
22. *Offem, J.O.:* Individual variation in the amino acid and chemical composition of defatted cocoa bean meal of three varieties of cocoa (Theobroma cacao) from South-eastern Nigeria. J. Sci. Food Agric. **52,** 129–135 (1990).

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