Cadmium and Cobalt in Tea and Coffee and their Relationship to Cardiovascular Disease

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SUMMARY

Both cadmium and cobalt are known to cause hypertension and cardiac pathology. Coffee drinking, but not tea drinking, has recently been implicated in the latter. Various brands of teas and coffees were analysed for cadmium and cobalt in order to discover whether these elements might be responsible for the deleterious effects of coffee.

Coffee infusions made from finely-ground coffee beans, coffee made from instant powders, one of pure coffee and 2 of coffee and chicory blends, and tea infusions, were analysed by atomic absorption spectrophotometry. The cadmium content of 5 teas, averaged, was found to be 0,0298 μg/g tea. That of 7 coffees was 0,03 μg/g coffee, the average of 3 different methods, each of which averaged 0,027, 0,018 and 0,045 μg/g coffee. Pure instant coffee powder had the highest cadmium content and bush tea the lowest.

The cobalt content of coffee was found to be considerably higher than that of tea. The content of 5 teas, averaged, was 0,20 μg/g tea and that of 7 coffees was 0,93 μg/g coffee, the average of 3 different methods, each of which averaged 0,75, 0,89 and 1,14 μg/g coffee. The cobalt content of pure instant coffee powder was the highest and that of bush tea and one other commercial brand of tea, the lowest.

In view of the fact that quantities of these elements ingested by even heavy coffee drinkers, form only a very small proportion of the total daily intake, no firm conclusions can be drawn about their toxicity from this source.

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Certain metallic elements in trace amounts are essential for various metabolic processes in man. They form metalloproteins and metallo-enzymes. For example, cobalt is an essential component of vitamin B_{12}, and zinc is found in dehydrogenases, anhydrases and carboxypeptidases. These essential roles are played at cellular levels of less than 0,01 ppm.[1]

Certain elements are, on the other hand, hazardous to health. Lead and mercury are well known for their toxic properties, and the symptomatology of toxic exposure is well documented. Cadmium is less well known as a toxic element, but is equally, if not more, dangerous. It has been said that 'environmental cadmium provides the most insidious and most widespread health hazard of any of the trace elements'.[2] It competes with and displaces zinc in enzyme systems,[3] so disrupting them, and it accumulates in the kidney, liver and aorta, in that order.[2] Deaths from cardiovascular diseases appear to be strongly correlated with high concentrations of airborne cadmium and cadmium in milk.[4-6] Chronic exposure leads to hypertension,[7] bone porosity and skeletal metabolic defects, which are associated with acute pain, resulting in the Japanese name of 'Itai-Itai' (agony) for the condition, first revealed as endemic among the inhabitants of the Jintsu River area in northern Japan.[8] Absorption of cadmium from the gut is inversely proportional to the zinc present, and much of this latter element is lost from food as a result of refining processes.[2]

Cobalt, too, can be toxic, in amounts that vary from individual to individual, since absorption is dependent on a number of factors such as quantity and type of dietary protein (in which methionine and cystine are important),[9] the pH of the stomach and upper duodenum,[10] and the presence or absence of iron deficiency.[11] Cobalt stimulates some enzyme systems and inhibits others,[12,13] it may block iodine uptake, the Krebs cycle and aerobic cellular respiration.[14,15] It accumulates in many organs, particularly the heart,[16,17] and has been shown to be the cause of cardiomyopathy which is defined as a functional insufficiency of cardiac muscle in beer drinkers in Quebec,[18] Omaha[19] and Louvain (Belgium).[20] It had been added for some months to beer as a froth stabiliser. The number of years of drinking and the daily consumption were the most important factors in determining the mortality rate (about 40%). In addition, cobalt chloride has been known for some time to produce endogenous hyperlipaemia in man and animals, consisting of the low density lipoproteins and their triglyceride components.[21]

Recently coffee drinking has been implicated in cardiovascular disease, the hardened coffee drinker being twice as liable to a myocardial infarction as a tea drinker.[22-24] In view of the fact that tea is not implicated and may even bestow some protective effect,[25] and that caffeine may not be the responsible factor,[21,26] the cadmium and cobalt content of each was determined in order to attempt to isolate other responsible factors.

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METHOD

Cadmium and cobalt estimations were performed on tea and coffee infusions, using tea leaves and finely-ground coffee beans, and on solutions of instant coffee powders, both pure and chicory blends. Ten grams of ground coffee beans, tea leaves and instant powders were weighed into beakers; 100 ml of distilled, de-ionised water was added to each sample and the mixture brought slowly to the boil. After a few minutes the solutions were filtered through Whatman No. 1 filter paper, and treated as described below.

Two analytical techniques were used: low-temperature ashing and wet digestion, the latter on coffee samples only.

In the low-temperature ashing, the filtered solutions were ashed in a muffle furnace for 4 hours at 350°C. They were removed, cooled and 10 ml concentrated HNO_3 added to each. They were then returned to the furnace and ashing allowed to proceed for a further 18 hours at 350°C.

The dry residue was dissolved in 10 ml 1N HCl, and 20 ml distilled water was added. The solution was then heated gently to evaporate excess volume and filtered through Whatman No. 1 filter paper. Filtrate volume was made up to 10 ml with distilled water.

This procedure was repeated with a duplicate set of coffee samples, omitting the final filtering, adding 10 ml 1N HCl only to the ashed samples.

In the wet digest method, 10 ml of concentrated HNO_3 was added to each filtered infusion or solution. After frothing had subsided 5 ml concentrated H_2SO_4 was added and the solution gently boiled. Ten millilitres of concentrated HNO_3 were then added, a little at a time while heating, until all colour disappeared. The samples were then evaporated to dryness, and the residue taken up in 10 ml of 1N HCl and heated gently for a few minutes.

Cadmium standards were made by diluting a stock solution of cadmium sulphate with 1N HCl so that their concentration fell in the range 50 - 200 μg/litre.

Cobalt standards were made up by diluting a stock solution of cobalt chloride with 1N HCl so that they fell in the concentration range 200 - 1000 μg/litre. Fe was added, as ferric chloride, to each standard in a concentration of 20 ppm (mg/litre) to ensure that Fe did not give spurious results since approximately 20 - 30 ppm Fe was found to be present in the final sample solutions.

Samples and standards were aspirated into a Varian Techtron atomic absorption spectrophotometer, Model No. AA1100. The apparatus was zeroed with 1N HCl. For cadmium estimations readings were taken at a wavelength of 228,8 nm, using a hollow cathode lamp, and for cobalt estimations readings were taken at 240,7 nm, using a cobalt-nickel hollow cathode lamp.

Recovery tests were performed on solutions of known cadmium and cobalt concentrations by subjecting them to the same treatment as the samples and determining their final concentration as described above.

RESULTS

Results are summarised in Tables I and II, and are given in μg/g tea or coffee and μg/cup of 180 ml. In the case of tea and coffee infusions these latter figures represent the maximal amount of element that could be ingested with the fluid, as a result, for example, of prolonged boiling or brewing. Both cadmium and cobalt salts are soluble in water.

TABLE I. CADMIUM CONTENT OF TEAS AND COFFEES

	LTA (final filtering)		LTA (no final filtering)		Wet digest	
Tea infusion	μg/g	μg/cup	μg/g	μg/cup	μg/g	μg/cup
Brand A	**0,028**	**0,112**				
„ B	**0,024**	**0,096**				
„ C	**0,025**	**0,100**	—		—	
Bush tea	**0,017**	**0,068**				
Brand D	**0,055**	**0,22**				
% recovery	**80%**					
Coffees						
Powder A	**0,017**	**0,05**	**0,027**	**0,08**	**0,042**	**0,13**
„ B	**0,013**	**0,06**	**0,024**	**0,12**	**0,045**	**0,23**
„ C (pure)	**0,035**	**0,06**	**0,07**	**0,35**	**0,09**	**0,45**
Infusion D	**0,013**	**0,19**	**0,015**	**0,22**	**0,032**	**0,48**
„ E	**0,015**	**0,22**	**0,017**	**0,25**	**0,035**	**0,52**
„ F	**0,020**	**0,3**	**0,015**	**0,22**	**0,042**	**0,63**
„ G	**0,010**	**0,15**	**0,022**	**0,33**	**0,030**	**0,45**
% recovery	**65%**		**95%**		**110%**	

1 cup of instant coffee contains ≈ 3 g powder;
1 cup of instant pure coffee (granules) contains ≈ 5 g granules;
1 cup of pure coffee infusion contains ≈ 15 g finely ground coffee;
1 cup of tea infusion contains ≈ 4 g tea;
1 cup contains 180 ml fluid.

TABLE II. COBALT CONTENT OF TEAS AND COFFEES

	LTA (final filtering)		LTA (no final filtering)		Wet digest	
Tea infusion	μg/g	μg/cup	μg/g	μg/cup	μg/g	μg/cup
Brand A	0,182	0,73				
„ B	0,16	0,64				
„ C	0,18	0,72	—		—	
Bush tea	0,16	0,64				
Brand D	0,34	1,36				
% recovery	92%					
Coffees						
Powder A	0,74	2,2	1,58	4,74	0,93	2,8
„ B	0,68	3,4	1,04	5,2	0,93	4,7
„ C (pure)	2,0	10,0	1,96	9,8	2,76	13,8
Infusion D	0,5	7,5	0,62	9,3	0,97	14,5
„ E	0,42	6,3	0,54	8,1	0,80	12,0
„ F	0,46	6,9	0,48	7,2	0,77	11,55
„ G	0,46	6,9	0,50	7,5	0,81	12,1
% recovery	100%		112%		140%	

1 cup of instant coffee contains ≈ 3 g powder;
1 cup of instant pure coffee (granules) contains ≈ 5 g granules;
1 cup of pure coffee infusion contains ≈ 15 g finely ground coffee;
1 cup of tea infusion contains ≈ 4 g tea;
1 cup contains 180 ml fluid.

The estimations on coffees presented some difficulties. Inorganic salts of cadmium have variable boiling points,[27] and it was found that considerable losses of Cd occurred if ashing was performed at temperatures above 400°C. At this temperature considerable organic matter remained. An earlier attempt to extract the element with solvents such as sodium diethyl dithiocarbamate and methyl isobutyl ketone was unsuccessful, since an oil/fat encrustation blocked the AAS nebulizer. The best method of determination appears to be the wet digestion as described above.

DISCUSSION

Cadmium

The cadmium contents of tea and coffee are not significantly different, but the values are considerably lower than those found in an earlier report.[28] However, the methods of making the infusions and their concentrations are not given.

On the basis of the values given in this report, 10 cups of either tea or coffee taken daily, provide a very small proportion of the tolerable weekly intake of 400 - 500 μg provisionally recommended by the FAO/WHO.[29] On the basis of Schroeder *et al.*'s[7,28] values of 10 - 50 μg/litre for tea and coffee, the consumption of 7 cups of either per day, means that up to 80% of the suggested weekly intake is being ingested by this route alone. If their values are correct, it may be advisable to limit the amount of tea and coffee taken. The toxicity of cadmium is, however, dependent on various factors, such as dietary zinc, protein, calcium and vitamin D.[2,29]

Cobalt

No recommendations are laid down about daily or weekly intake of cobalt. In the Omaha episode, cobalt was added to the beer in a concentration of 1,1 - 1,2 ppm (mg/litre).[17] A heavy drinker might consume 4 litres per day and hence ingest about 4 mg Co. In the Quebec incident, an amount of 24 pints of beer is given as being consumed by a heavy drinker and as containing 8 mg of Co as the sulphate salt.[18] However, these authors mention that a proprietary brand of an anti-anaemic agent contains 15 mg cobalt chloride combined with 100 mg ferrous sulphate in a single tablet, 4 of which are recommended as a daily dose. They note that 60 mg Co per day does not appear to have any devastating effect. Protection is perhaps afforded by the iron present. Children on such preparations do develop goitre.[30]

The amounts of cobalt found in the instant coffees agree with those of Schroeder *et al.*[30] Table II shows that coffee contains considerably more Co than tea. A drinker consuming 7 cups of coffee made from instant brand C per day (1 litre) would be ingesting about 0,1 mg Co, an amount 2 500 times more than the daily estimated requirement of 0,04 μg for the synthesis of vitamin B_{12}.[30] Coffees on average contain the largest amounts of cobalt of all foodstuffs consumed by man on a μg/g basis,[30] but this amount provides only a small proportion of total cobalt intake from all sources. It is nevertheless interesting to note that both cobalt[31] and coffee[32,33] raise the serum lipids, a possible explanation for the relationship of the latter to cardiovascular disease. The amounts of cobalt required to induce hypercholesterolaemia[31] are far in excess of the amount ingested in the coffee, and the link between the two has not yet been established.

The effects of cobalt ingestion in people with iron deficiencies, protein deficiencies and general dietary imbalances, require further investigation. It would be of interest to analyse the Co content of the various home-made Bantu beers to attempt to explain the high incidence of cardiomyopathies among the Black people. A long period of ingestion of more than optimal amounts of cobalt, concomitant with undernutrition (which can be defined as an imbalance of nutrients), or malnutrition (the absence of certain essential nutrients), may ultimately lead to metabolic defects.

In conclusion, neither cobalt nor cadmium can be implicated as a cause of cardiovascular disease, as shown by the results of this report.

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