The Heavy Metal Content of Fruit Juices and Carbonated Beverages by Atomic Absorption Spectrophotometry

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Fruit juices and carbonated beverages are consumed on an average by Canadians at the rate of 80 g. per day per person, or approximately 5% of the total diet (1, 2, 3). It is well known that fruit juices contain traces of heavy metals such as manganese, cobalt, nickel, zinc, and copper (4, 5). Therefore, the heavy metal contribution of fruit juices and carbonated beverages to the total diet cannot be neglected.

Atomic absorption spectrophotometry is a rapid and accurate method for the determination of trace elements. Carbonated beverages can be analysed directly after removal of carbon dioxide by evaporation (6, 7). With fruit juices large particles must first be removed by centrifuging, and interference from sugar is compensated for by using the method of additions (8).

Experimental

Standard Solution: A multi-element standard solution of 9 metals was prepared to give the following concentration when diluted a hundred fold:

Cu 1.0 µg/ml, Zn 0.2 µg/ml, Ni 0.2 µg/ml, Cr 0.2 µg/ml, Mn 0.05 µg/ml, Pb 0.5 µg/ml, Cd 0.5 µg/ml, Co 0.2 µg/ml, and Sn 10.0 µg/ml.

Sample preparation for fruit juices: Fruit juices were centrifuged for 15 minutes at 4500 r.p.m. to obtain pulp-free liquid. Aliquots 0, 1, 2 and 3 ml of the multi-element standard solution were added to 100 ml volumetric flasks containing 3, 2, 1 and 0 ml of distilled water respectively and diluted to 100 ml with clear juice.

Sample preparation for carbonated beverages: Four 100 ml aliquots of beverages were pipetted into 250 ml beakers containing 0, 1, 2 and 3 ml of multi-element standard respectively. After heating on a hot plate until the volume was reduced to 75 ml the samples were cooled and diluted to 100 ml.

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Atomic absorption: A Perkin Elmer Model 303 atomic absorption spectrophotometer equipped with a boling burner and a null recorder read-out accessory was used. (The prepared samples were aspirated directly in the spectrophotometer). The operating parameters are given in (table 1).

TABLE 1

Operating Parameters

	Cd	Co	Cr	Cu	Ni	Pb	Zn	Mn	Sn
Wave-length Å	2288	2407	3579	3247	2320	2170	2138	2795	2246
Slit width, mm.	1	0.3	0.3	1	0.3	1	3	1	1
Source, ma.	6	30	20	20	30	12	15	20	25
Air flow	8	9.7	9	9.2	9	9	9.2	9	9
Acetylene flow	9	8.0	9	8	9	9	8	9	9
Gain	6.3	6.1	5.8	5.7	6.2	6.3	5.4	5.4	5.7
Scale expansion	3x	3x	3x	1x	3x	3x	1x	3x	1x

Results and Discussion

The heavy metal content of fruit juices has been the subject of a number of investigations. Levels of lead, cadmium, copper and zinc of <0.05 p.p.m., 0.05 p.p.m., 0.3 - 1.1 p.p.m. and 1.3 - 8.6 p.p.m. respectively have been reported by Westöö (9). Picasso de Micheli (10) found the average zinc content of canned sweetened juices to be 10.6 p.p.m. Values up to 2.1 p.p.m. for manganese and 150 p.p.m. for tin, have been found in citrus juices by Castro (11) and by Oda (12) respectively.

The heavy metal content of ten fruit juices (Table 2) is in general agreement with previously reported data with the exception of manganese in pineapple juice and lead in lemon and lime juice in which higher levels were detected. The presence of cadmium and cobalt was not detected in any of the fruit juices examined.

TABLE 2

The heavy metal content (p.p.m.)[a] of ten fruit juices

Type of juice	Cr p.p.m.	Cu p.p.m.	Ni p.p.m.	Pb p.p.m.	Mn p.p.m.	Zn p.p.m.	Sn p.p.m.
Grape	.08	<.1	<.02	<.08	.84	.38	<2
Prune	.15	.55	<.02	<.08	1.3	1.63	<2
Hawaiian Punch	<.01	<.1	<.02	<.08	1.3	27	<2
Pineapple	<.01	<.1	.28	<.08	16	.93	46
Apple	<.01	.26	<.02	<.08	.53	.17	<2
Orange	<.01	.25	.06	<.08	.45	.19	59
Grapefruit	<.01	<.1	.17	<.08	.18	.27	43
Lime	.24	.85	.40	.30	.26	.97	<2
Tangerine	<.01	.25	.08	<.08	.40	.56	114
Lemon	.05	.69	<.02	.57	.23	.93	<2

[a] In all fruit juices Cd <.01 p.p.m., Co <.03 p.p.m.

Less attention appears to have been given to the analysis of metals in carbonated beverages, although Larkin (13) has found up to .1 p.p.m. and 3.2 p.p.m. for lead and zinc respectively, and Sanz Pedrero (14) up to .65 p.p.m. for lead.

In the present survey, when possible, bottled and canned samples of the same brand were obtained and analysed. Lead, cobalt, copper, chromium, and cadmium could not be detected in any of the samples (Table 3). From these data it can be observed that the zinc content of canned beverages is much higher than that found in bottled samples, and in one cola sample was as high as 6.8 p.p.m.

TABLE 3

The heavy metal content (p.p.m.)[a] of twenty three carbonated beverages

Type of carbonated beverage	Type of container	Ni p.p.m.	Mn p.p.m.	Zn p.p.m.	Sn p.p.m.
Ginger ale	Bottle	<.02	<.01	<.02	<2
	Can	"	"	.08	8
Ginger ale	Bottle	"	"	<.02	<2
	Can	"	"	2.2	"
Lemon flavoured	Bottle	"	"	.07	"
	Can	"	"	3.3	"

TABLE 3 - Continued

Type of carbonated beverage	Type of container	Ni p.p.m.	Mn p.p.m.	Zn p.p.m.	Sn p.p.m.
Lemon flavoured	Bottle	<.02	<.01	.02	<2
	Can	"	"	.02	"
Lemon flavoured	Bottle	"	"	<.02	"
	Can	"	.03	1.9	"
Soda water	Bottle	"	<.01	<.02	"
	Can	"	"	2.0	"
Cola	Bottle	"	"	.05	"
	Can	"	"	.07	"
Cola	Bottle	"	"	<.02	"
	Can	"	"	.07	"
Root beer	Can	"	"	3.2	"
Grape	Can	"	.02	2.3	"
Orange	Can	"	<.01	2.7	"
Lemon flavoured Low Cal.	Bottle	"	"	<.02	"
Lemon flavoured Low Cal.	Can	"	"	5.5	"
Cola Low Cal.	Can	.07	.02	.15	"
Cola Low Cal.	Can	<.02	"	6.8	"

[a] In all carbonated beverages Cd <.01 p.p.m.
Cr <.01 p.p.m.
Cu <.1 p.p.m.
Co <.03 p.p.m.
Pb <.08 p.p.m.

The levels of heavy metals found in fruit juices are generally within the limits of the Canadian Food and Drug regulations. The relatively high concentration of lead in lemon and lime juice and manganese in pineapple juice indicate the need for a more detailed study of these juices. The carbonated beverages on the other hand are relatively heavy metal free except the zinc content of canned beverages and as such offer no specific problem areas.

The average percentage deviation of the calibration curve for 72 additions of each metal ranged from .8% for copper to 4.0% for lead. It is apparent therefore, that atomic absorption spectrophotometry is a reliable method for the direct determination of heavy metals in fruit juices and carbonated beverages.

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