A Survey of N-Nitrosodimethylamine in U.S. and Canadian Beers†

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A total of 194 beers (148 from the United States and 46 from Canada) were analyzed for volatile N-nitrosamines. The sampling was designed to include different types of beers brewed from malts from all commercial scale malt houses by the major beer companies in both countries. N-Nitrosodimethylamine (NDMA), the only volatile N-nitrosamine detected, was found in 55% of the U.S. and 59% of the Canadian beers at or above the lowest detection level of 0.05 μg/kg. The mean NDMA level for all 194 beers was 0.074 μg/kg, and the range was ND–0.58 μg/kg. The results indicate that NDMA levels in present-day U.S. and Canadian beers are approximately 1–5% of what they were a decade ago.

Immediately following initial reports of N-nitrosodimethylamine (NDMA) in beer, approximately 10 years ago, investigators from a number of countries reported that mean NDMA values of 1–6 μg/kg were common. Mangino et al. (1981) compiled a summary of studies that included NDMA levels in beer during the time period from 1978 to mid-1979, and this information is shown in Table I. Soon after the initial reports of NDMA in beer, the brewing and malting industries in a number of countries investigated ways to reduce NDMA levels in beer. It was found that NDMA formed during the direct-fired drying of malt and preventive strategies focused on modification of that process (Scanlan, 1983). Although introduction of sulfur dioxide into the drying air of direct-fired kilns substantially reduced nitrosamine formation (O'Brien et al., 1980), conversion of kilns to the indirect-fired type was found to be more effective for reducing nitrosamine formation (Hardwick et al., 1981). Consequently, maltsters converted their kilns from direct-fired to the indirect-fired type in the early part of this decade in order to reduce nitrosamine formation.

Although it is generally known that conversion to indirect-fired kilns has reduced NDMA formation, data in the literature are very scarce on current NDMA levels in beer. Accurate information on exposure to carcinogens is very important for investigators attempting to elucidate the roles of various dietary carcinogens in the etiology of human cancer. The purpose of this report is to provide current information on the levels of NDMA in U.S. and Canadian beers.

PROCEDURES

Sampling Method. The sampling plan was designed to include beers representative of current manufacture in the United States and Canada. Included were the four types indicated in Tables II and III. The sampling included beers brewed with malts from all commercial scale malting houses in both countries. Samples of bottled or canned beers that represent the major domestic brands in the United States were obtained on the open market either by Danis Research, Fairfield, NJ, or by us. Samples of bottled or canned beer representing the major domestic brands in Canada were obtained on the open market by CanTox., Oakville, Ontario.

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Table I. Initial Reports of N-Nitrosodimethylamine in Beers[a]

investigators	source	range[b]	mean
Spiegelhalder et al., 1979	European + imported	ND–68	2.7
Walker et al., 1979	European + imported	ND–10.8	1.9
Goff and Fine, 1979	U.S. + imported	0.4–7	2.8
Scanlan et al., 1980	U.S.	ND–14	5.9
Sen et al., 1980	Canadian + imported	ND–4.9	1.5
Fazio et al., 1980	U.S. + imported	ND–7.7	2.8
Kawabata et al., 1980	Japan	tr–13.8	5.1
Kann et al., 1980	USSR	ND–56	–

[a] Micrograms per kilogram. [b] ND = none detected.

The U.S. sampling included 148 beers representing the production of four major companies and 25 breweries. In Canada, the sampling included 46 beers representing all major brands from the eight largest companies and included products from breweries in all 10 provinces. All the beers in this study were manufactured in 1988.

Analysis. The beers were analyzed for volatile N-nitrosamines according to the Celite column procedure described by Hotchkiss et al. (1981) and Marinelli (1981) except the sample size was increased from 25.0 to 50.0 g. The increased sample size allowed a lower detection level of 0.05 μg/kg. Detection was by gas chromatography–thermal energy analysis (Marinelli, 1981). In this procedure, the amount of NDMA is corrected for recovery by use of N-nitrosodipropylamine as an internal standard.

RESULTS

The results of analysis of the U.S. beers are shown in Table II, and the results of analysis of the Canadian beers are shown in Table III. NDMA was the only volatile N-nitrosamine detected in any of the samples. Of the USA beers 55% and of the Canadian beers 59% contained NDMA at or above the lower detection level of 0.05 μg/kg. In an overall sense, the levels of NDMA in the four different types of beers from the two countries were very similar. When the NDMA values of beers from both countries are combined, the mean NDMA level for all 194 beers was 0.074 μg/kg and the range was ND–0.58 μg/kg.

DISCUSSION

When one compares the results from this study with U.S. and Canadian data contained in Table I, it is evident that NDMA levels in beer currently produced are approximately 1–5% of the levels found in beers from these two countries a decade ago. Comparison of recent

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Table II. N-Nitrosodimethylamine Levels in U.S. Beers[a]

type of beer	no. of samples	no. of samples with NDMA levels of <0.05	0.05–0.09	0.10–0.19	0.20–0.39	0.40–0.59	mean[b]	median
lager	81	34	22	21	4	0	0.06	0.07
light	49	29	14	4	0	2	0.05	<0.05
malt liquor	12	2	3	5	2	0	0.10	0.12
ale	6	2	2	0	1	1	0.13	0.06
total	148	67	41	30	7	3	0.067	0.050

[a] Micrograms per kilogram. [b] Zero was used for <0.05.

Table III. N-Nitrosodimethylamine Levels in Canadian Beers[a]

type of beer	no. of samples	no. of samples with NDMA levels of <0.05	0.05–0.09	0.10–0.19	0.20–0.39	0.40–0.59	mean[b]	median
lager	17	7	3	5	1	1	0.09	0.07
light	13	7	4	0	2	0	0.07	<0.05
malt liquor	5	1	0	3	1	0	0.16	0.16
ale	11	4	2	3	2	0	0.11	0.06
total	46	19	9	11	6	1	0.095[b]	0.060

[a] Micrograms per kilogram. [b] Zero was used for <0.05.

reports from the United States (Billedeau et al., 1988), Sweden (Osterdahl, 1988), Italy (Gavinelli et al., 1988), The Federal Republic of Germany (Frommberger, 1989), and Poland (Kubacki et al., 1989) also indicate markedly lower NDMA values than generally observed a decade ago. The results of this study, as well as the investigations cited above, reflect the successful efforts of the malting and brewing industries to reduce NDMA formation.

In 1981, a committee of the National Academy of Sciences (NAS), using an NDMA level in beer of 2.8 μg/L, estimated a daily exposure of 0.97 μg of NDMA/person in the United States (National Academy of Sciences, 1981). Using the same beer consumption figures as used by the NAS in 1981, with the overall mean NDMA level of 0.074 μg/kg from this study, the daily exposure of NDMA per person is estimated to be 0.026 μg. This is 2–3% of the exposure to NDMA from beer estimated by the NAS in 1981. The results from this investigation indicate that exposure to NDMA from present-day beer consumption is markedly less than that of a decade ago.

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