LIQUID HERBAL DIETARY SUPPLEMENTS PRESERVED WITH BENZOATES AS POSSIBLE SOURCE OF BENZENE

INTRODUCTION:

Liquid dietary supplements often contain preservatives, among others, benzoates, used for prolongation of product's shelf-life. Ascorbic acid, naturally present in plants or added as vitamin C or a food additive (antioxidant), can react with benzoates under certain conditions (e.g. heat, UV-light) to form benzene. Benzene is a known human carcinogen, and thus its ingestion in the diet could pose risk for consumers' health. Low levels of benzene have even been found in a variety of foods without added benzoates. In such cases, benzene is considered naturally occurring substance. Higher levels of benzene were found in some, but not all, foods preserved with benzoates.

OBJECTIVES:

Study objective was to investigate benzene occurrence in liquid dietary supplements preserved with benzoates and consequent exposure of consumers.

METHOD / DESIGN:

Thirty-four herbal dietary supplements, purchased in pharmacies in Novi Sad in 2021, were liquids with benzoates (sodium benzoate) on their ingredients list. Additional 18 samples of liquid herbal dietary supplements preserved with sorbates (without benzoates) were acquired for the purpose of benzene analysis quality control (similar matrix containing herbal extracts, expected blanks). The method of analysis was HPLC-UV for preservatives, whereas benzene analysis was carried out using HSS-GC-MS. Benzene exposure assessment was based on experimentally obtained concentration data and products' usage instructions given on the labels. Health risk was assessed based on comparison of estimated exposure with Oral Reference Dose for benzene of 0.004 mg/kg bw/day (RfD, U.S. EPA).

Table. Benzene content, consequent exposure and %RfD, with corresponding sodium-benzoate and ethanol content, for 14 investigated samples in which benzene was detected.

Sample number	Package	Shelf life	Ingredients	Population	Usage instructions	Benzene (ng/mL)	Benzene intake (ng/kg bw/day)	Benzene % RfD	Na-benzoate (mg/L)	Ethanol (mg/L)
1	200 g	2023 09	β-glucan, zinc, vitamin C	children 3-7 years	1 ml / 5 kg bw	37.4	7.45	0.19	1415	<LOQ
2	125 ml	2021 11	marsh mallow, chamomile, rose hip, basil	children 1-3 years	3 x 1 cs (5 ml)	12.4	15.50	0.39	1966	10641
3	140 g	2022 06	marsh mallow, chamomile, vitamin C	children >12 years	4 x 1 ts (15 ml)	5.3	6.14	0.15	1254	55755
4	140 g	2022 06	primrose, thyme, vitamin C	children >12 years	4 x 1 ts (15 ml)	9.1	10.54	0.26	1143	57855
5	125 ml	2022 05	marsh mallow, thyme, menthol, vitamin C	children 4-7 years	3 x 1/2 cs (5 ml)	7.4	2.40	0.06	663	19169
6	125 ml	2022 03	marsh mallow, vitamin C	children 3-7 years	3 x 5 ml	4.3	2.79	0.07	1435	10297
7	120 ml	2022 02	marsh mallow, honey, propolis, primrose, mint	children 6-12 years	2-3 x 12 ml	11.7	12.70	0.32	2071	34993
8	125 ml	2021 12	thyme, primrose, vitamin C	children >10 years	4 x 1 cs (5 ml)	3.1	1.20	0.03	1461	32544
9	150 g	2021 10	ivy	children 3-6 years	1 x 2,5 ml	1.2	0.13	0.00	1262	<LOQ
10	140 g	2022 06	plantago, thyme, primrose, vitamin C	adults	4 x 1 ts (15 ml)	5.1	4.01	0.10	1185	70811
11	150 ml	2022 07	β-glucan, spirulina, vitamin C,D, selenium, zinc, iodine	children 3-6 years	1 x 1 cs (5 ml)	54.2	11.73	0.29	1294	<LOQ
12	125 ml	2022 09	marsh mallow, primrose, chamomile, basil, vitamin C	children 3-7 years	3 x 1 cs (5 ml)	26.4	17.14	0.43	1872	31546
13	120 ml	2022 07	marsh mallow, honey, propolis, rose hip	children 3-6 years	2-3 x 12 ml	17.9	27.90	0.70	1958	35672
14	250 ml	2022 09	marsh mallow, primrose, chamomile, basil, vitamin C	children 3-7 years	3 x 1 cs (5 ml)	38.7	25.13	0.63	2123	26560

RESULTS:

Analysis of preservatives confirmed their presence as presented on the products' labels. Sodium benzoate concentrations ranged from 663 to 8037 mg/L. Benzene was detected in 14 out of 34 samples (41.2%), in concentration ranging from 1.2 to 54.2 μg/L, in samples containing sodium benzoate in concentration range 663-2123 mg/L. No correlation was established between concentrations of sodium benzoate and benzene. Benzene was not detected in any of the samples preserved using sorbates (confirmed blanks).

Measured levels of benzene were greater than maximum allowed concentration of benzene in drinking water in the Republic of Serbia, set at 1 μg/L. It was interesting to note that one of six producers of 14 samples with measurable amounts of benzene was associated to even 5 samples (36%), mostly with higher range benzene content.

Regarding exposure assessment, it has to be highlighted that out of 23 samples intended for adults 8 were positive for benzene, 12 out of 27 for adolescents, 11 out of 25 for children (7-10 year), 10 out of 25 for preschool children, and one out of 8 for toddlers.

Compared with RfD of benzene, the one benzene containing sample intended for toddlers was responsible for low level exposure (0.39% of RfD), exposure of preschool children ranged from 0.003-0.70%, children 0.005-0.65%, adolescents 0.006-0.84%, and adults 0.036-0.57%.

These products are used over a limited period of time, usually to support respiratory or immune system, and therefore exposure to benzene caused by their consumption is also limited. However, considering the fact that co-exposure to benzene and ethanol can increase benzene toxicity in humans, it is important to emphasize that many of investigated products contain ethanol used for preparation of plant extracts which were their active principles.

CONCLUSIONS:

Considering that children constitute a group that is consuming majority of investigated liquid herbal supplements, it is of the utmost importance to prevent benzene presence. Indeed, product reformulation could eliminate in situ benzene generation and thus mitigate health risk.

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