Heavy Metals in Chocolate Bars

The purpose of this study was to determine the levels of arsenic, cadmium, lead, and mercury in 28 well-known models (21 brands) of dark chocolate bars, and to assess any associated health risk(s). We tested 2-3 samples with at least two distinct lot codes of each model, all of which were selected based on online store surveys. We purchased the majority of the samples between April and May 2022 from online and stores in the New York area. Most of the models were nationally available though some store brands were included.

SAMPLE PREPARATION

The samples were masked, blind coded to preserve their identities, and shipped overnight to an independent, accredited laboratory for the analyses. At the lab, sample preparation or homogenization was performed in fume hoods known to be free from trace metals contamination. Water, sample containers and other materials used for the analyses were monitored for contamination, where appropriate, to account for any biases in sample results.

TESTING

Analysis for Arsenic, Cadmium, Lead, and Mercury by Triple Quadrupole Inductively Coupled Plasma Mass Spectrometry (IC-QQQ-MS), with Collision Cell Reaction (CRC)
The samples were prepared and analyzed in accordance with the Association of Official Analytical Chemists (AOAC) Method 2015.01.

Arsenic Speciation Analysis by Ion Chromatography-Inductively Coupled Plasma-Collision Reaction Cell-Mass Spectrometry (IC-ICP-CRC-MS)
A subset of the samples covering the range of measured total arsenic was analyzed for total inorganic arsenic and three organic arsenic species - monomethyl arsonic acid (MMA), dimethyl arsinic acid (DMA), and trimethylarsine oxide (TMAO).

Sample analyses were precluded by at least a five-point calibration curve spanning the entire concentration range of interest. Calibration curves were performed at the beginning of each analytical day and verified during analysis. The testing conformed to the quality control criteria and performance requirements set in cited official methods, as well as to those under the lab's ISO 17025 accreditation.

RISK ASSESSMENT

We estimated daily consumption of the chocolate bars using both the label serving size and the one ounce or 30 grams per eating occasion FDA Center for Food Safety and Applied Nutrition (CFSAN) reference amount customarily consumed (RACC) of chocolate, our test results, and the average body weights of adults. We used the recommended adult body weight from the EPA (2011 Exposure Factors Handbook). For heavy metals test results below the method detection limit (MDL), we used the method from Xue et al. (2010) to estimate the average concentration of a model. If the metal was detected in any of the two-three samples of a model, then test results for that model that were below the MDL were assumed to have a concentration of half the MDL. If the metal was not detected in any of the samples tested of a model, we assumed a concentration of zero for all of the samples of that model.

Non-Cancer Health Risks from Estimated Daily Intakes of Inorganic Arsenic, Cadmium, Lead, and Methyl Mercury

SELECTED HEALTH-BASED EXPOSURE AND OTHER LIMITS			
Heavy Metal	**Source**	**Endpoint and Basis for Limit**	**Value** (Unit)
Inorganic Arsenic	EPA (1991) (currently under review)	Non-cancer oral reference dose based on hyperpigmentation, keratosis, and possible vascular complications from chronic human exposures	0.3 ug/kg-day (upper limit)
		Lower bound of suggested range whereby 0.8 ug/kg/day was the upper bound	0.1 ug/kg-day (lower limit)
Cadmium	OEHHA (2017)	OEHHA Proposition 65 Maximum Allowable Dose Level (MADL) for Chemicals Causing Reproductive Toxicity (cadmium, oral exposure)	4.1 ug/day
Lead	OEHHA (2017)	OEHHA Proposition 65 Maximum Allowable Dose Level (MADL) for Chemicals Causing Reproductive Toxicity (total lead, oral exposure)	0.5 ug/day
Methyl Mercury	EPA (Updated 2001, currently under review)	Non-cancer oral reference dose based on developmental neuropsychological impairment	0.1 ug/kg-day

We compared our estimated daily intakes to health-based limits in the above table, and estimated the percent contributions to the limits for each metal. We set 100% of the daily limit of lead and cadmium as the acceptable threshold below which a tested product could be considered less concerning regarding the exposure of consumers to lead and cadmium from solely the tested chocolate bars. *We considered as our rationale for this threshold the assumptions that consumption of chocolate bars is occasional for most people, and the exceedances of the referenced daily limits for cadmium and lead are more infrequent.*