核农学报 2011, 25(3) 534-539 DOI: ISSN: 1000-8551 CN: 11-2265/S

论文

铅同位素比率分析技术在食品污染源解析中的应用

赵多勇, 魏益民, 郭波莉, 魏帅

中国农业科学院农产品加工研究所/农业部农产品加工与质量控制重点开放实验室,北京 100193

摘要:

铅是一种有毒有害重金属,可通过膳食、呼吸等途径进入人体,并蓄积达到有害水平。由于食用农产品产地环境不断受到铅的污染,使得"从农田到餐桌"食品供应链在最初环节存在较大的风险,因此土壤、大气等环境介质成为食品铅污染的可能来源。为准确找到污染源并及时切断污染途径,降低危害发生的概率,追溯食品中铅污染物的来源显得尤为重要。铅同位素比率分析技术是追溯铅来源的一种有效方法,该方法结合相应模型可推测食品铅污染的来源及各污染源的相对贡献率。本文阐述了食品中铅污染物的来源,铅同位素比率分析技术溯源的原理、方法,以及该方法在蔬菜、茶叶、葡萄酒、谷物等食品铅污染物溯源中的应用现状,旨在为食品铅污染溯源和控制提供理论和技术参考。

关键词: 铅 食品 污染源 同位素比率 解析

APPLICATIONS OF LEAD ISOTOPE RATIOS FOR IDENTIFICATION AND APPORTIONMENT ON POLLUTION SOURCES IN FOOD

ZHAO Duo-yong, WEI Yi-min, GUO Bo-li, WEI Shuai

Key Laboratory of Agriculture Product Processing and Quality Control, Ministry of Agriculture/Institute of Agro-Food Science and Technology, Chinese Academy of Agricultural Sciences, Beijing 100193

Abstract:

Lead is one of the toxic heavy metals which can accumulate to an adverse effect level in human bodies through ingestion, inhalation or other pathways. Because of the persistent lead contamination in farmland environment, large risk exists in the primary stage of "from farm to table" chain. Environmental media such as soils, atmospheric aerosols were the possible lead sources of agro-food. To prinpoint the pollution sources exactly, cut off the contamination pathways in time, and reduce the risk of hazard, pollution sources tracing was very important. Lead isotope ratio combined with certain models is an effective method to discriminate correctly the pollution sources and calculate the individual source contributions. In this review, to provide theoretical and technical reference for controlling lead pollution in environment and food, lead pollution sources in food, tracing principle and methods of lead isotope ratios, and its applications on vegetable, tea, wine, cereal and other food products were concerned.

Keywords: Lead food pollution source isotope ratios identification and apportionment

收稿日期 2010-03-31 **修回日期** 2010-06-01 **网络版发布日期**

DOI:

基金项目:

农业部948项目(2009-Z45),农业部农业行业标准制定和修订(2011-403)

通讯作者: 魏益民(1957-),男,陕西咸阳人,博士,教授,研究方向为食品质量与安全。E-mail:weiyimin36@hotmail.com

作者简介: 赵多勇(1980-),男,新疆奇台人,在读博士,研究方向为食品质量与安全。E-mail:Luckydyz@163.com

作者Email: weiyimin36@hotmail.com

参考文献:

[1] 常元勋. 金属毒理学
[M]. 北京: 北京大学医学出版社, 2008:217-346

[2] Duzgoren-Aydin N S. Sources and characteristics of lead pollution in the urban environment of Guangzhou
[J]. Science of the Total Environment, 2007, 385: 182-195

[3] Hou X, Parent M, Savard M M, et al. Lead concentrations and isotope ratios in the exchangeable fraction: tracing soil contamination near a copper smelter
[J]. Geochemistry: Exploration, Environment, Analysis, 2006, 6: 229-236

[4] Chen J M, Tan M G, Li Y L, et al. A lead isotope record of shanghai atmospheric lead emissions in total suspended particles during the period of phasing out of leaded gasoline
[J]. Atmospheric Environment, 2005, 39: 1245-1253

[5] 吴龙华, 张长波, 章海波, 骆永明. 铅稳定同位素在土壤污染物来源识别中的应用
[J]. 环境科学, 2009, 30(1): 227-230

[6] Harrison R M, Chirgawi M B. The assessment of air and soil as contributors of some trace metals to vegetable plants I. Use of a filtered air growth cabinet
[J]. Science of the Total Environment, 1989, 83: 13-34

[7] Sharma R K, Agrawal M, Marshall F M. Heavy metal(Cu, Zn, Cd and Pb)contamination of vegetables in urban India: A case study in Varanasi
[J]. Environmental Pollution, 2008, 154: 254-263

[8] Wang G, Su M Y, Chen Y H, et al. Transfer characteristics of cadmium and lead from soil to the edible parts of six vegetable species in southeastern China
[J]. Environmental Pollution, 2006, 144: 127-135

[9] Bi X Y, Feng X B, Yang Y G, et al. Allocation and source attribution of lead and cadmium in maize (*Zea may* L.) impacted by smelting emissions
[J]. Environmental Pollution, 2009, 157: 834-839

[10] Cheng H F, Hu Y A. Lead (Pb) isotopic fingerprinting and its applications in lead pollution studies in China: A review
[J]. Environmental Pollution, 2010, 158: 1134-1146

[11] 金正耀. 铅同位素示踪方法应用于考古研究的进展
[J]. 地球学报, 2003, 24(6): 548-551

[12] Sealy J C, Armstrong R, Schrire C. Beyond lifetime averages: tracing life histories through isotopic analysis of different calcified tissues from archaeological skeletons
[J]. Antiquity, 1995, 69: 290-300

[13] Budd P, Montgomery J, Cox A, et al. The distribution of lead within ancient and modern human teeth: Implications for long-term and historical exposure monitoring
[J]. The Science of the Total Environment, 1998, 220: 121-136

[14] Brill R H, Yamasaki K, Barnes I L, et al. Lead isotopes in some Japanese and Chinese glasses
[J]. Ars orientalis, 1979, 13: 87-109

[15] Doe B R. Lead Isotopes
[M]. Springer-Verlag, Berlin Heidelberg, New York, 1970:1-10

[16] 吴开兴, 胡瑞忠, 毕献武, 彭建堂, 唐群力. 矿石铅同位素示踪成矿物质来源综述
[J]. 地质地球化学, 2002, 30(3): 73-81

[17] Sturges W T, Barrie L A. The use of stable lead 206/207 isotope ratios and elemental composition to discriminate the origins of lead in aerosols at a rural site in eastern Canada
[J]. Atmospheric Environment, 1989, 23(8): 1645-1657

[18] Flament P, Bertho M L, Deboudt K, et al. European isotopic signatures for lead in atmospheric aerosols: a source apportionment based upon $^{206}Pb/^{207}Pb$ ratios
[J]. The Science of the Total Environment, 2002, 296: 35-57

[19] 王 琬, 刘咸德, 鲁毅强, 郭冬发, 李玉武, 田肖丹, Adams F. 北京冬季大气颗粒物中铅的同位素丰度比的测

定和来源研究
[J]. 质谱学报, 2002, 23(1): 21-29

[20] 李显芳, 刘咸德, 李 冰, 董树屏, 刘 锋, Lierde V V, Vanhaecke F. 北京大气$PM_{2.5}$中铅的同位素测定和来源研究
[J]. 环境科学, 2006, 27(3): 401-407

[21] Rosman K J R, Taylor P D P. IUPAC table of isotopic compositions of the elements
[J]. Pure and Applied Chemistry, 1998, 70(1): 217-235

[22] Erel Y. Mechanisms and velocities of anthropogenic Pb migration in Mediterranean soils
[J]. Environmental research, Section A, 1998, 78: 112-117

[23] Gulson B. Stable lead isotopes in environmental health with emphasis on human investigations
[J]. Science of the Total Environment, 2008, 400: 75-92

[24] Monna F, Lancelot J, Croudace I W, et al. Pb isotopic composition of airborne partiduce materical from France and the sourthern united kingdom:Implications for Pb pollution sources in urban areas
[J]. Environmental Science Technology, 1997,31:2277-2286.

[25] Hopper J F, Ross H B, Syurges W T, et al. Regional source discrimination of atmospheric aerosols in Europe using the isotopic composition of lead
[J]. Tellus, 1991, 43B: 45-60

[26] Chiaradia M, Chenhall B E, Depers A M, et al. Identification of historical lead sources in roof dusts and recent lake sediments from an industrialized area: indications from lead isotopes
[J]. The Science of the Total Environment, 1997, 205: 107-128

[27] Gobeil C. Sources and burden of lead in St. lawrence estuary sediments: isotopic evidence
[J]. Environmental Science Technology, 1995, 29: 193-201

[28] 陈天金. 铅高暴露地区人群膳食安全暴露评估
[D]. 陕西: 西北农林科技大学, 2006:24-30

[29] 吴双桃, 朱 慧. 市郊公路边上土壤和蔬菜中重金属含量特征
[J]. 湖北农业科学, 2009, 48(3): 587-589

[30] Hu X, Ding Z H. Lead/Cadmium contamination and lead isotopic ratios in vegetables grown in Vegetables Grown in Peri-Urban and mining/smelting contaminated sites in Nanjing, China
[J]. Bulletin of Environmental Contamination and Toxicology, 2009, 82: 80-84

[31] 胡 忻, 曹 密. 农田蔬菜中重金属污染和铅稳定同位素特征分析
[J]. 环境污染与防治, 2009, 31(3): 102-104

[32] 李 勇. 植源性食品产地及铅污染溯源技术研究
[D]. 北京: 中国农业科学院, 2008: 53-60, 111-112

[33] Han W Y, Zhao F J, Shi Y Z, et al. Scale and causes of lead contamination in Chinese tea
[J]. Environmental Pollution, 2006, 139: 125-132

[34] Jin C W, Zheng S J, He Y F, et al. Lead contamination in tea garden soils and factors affecting its bioavailability
[J]. Chemosphere, 2005, 59: 1151-1159

[35] Han W Y, Shi Y Z, Ma L F, et al. Effect of liming and seasonal variation on lead concentration of tea plant (*Camellia sinensis* (L.) O. Kuntze)
[J]. Chemosphere, 2007, 66: 84-90

[36] Jin C W, He Y F, Zhang K, et al. Lead contamination in tea leaves and non-edaphic factors affecting it
[J]. Chemosphere, 2005, 61: 726-732

[37] 郦逸根, 路远发. 西湖茶园茶叶铅污染铅同位素示踪
[J]. 物探与化探, 2008, 32(2): 180-185

[38] 杨红梅, 路远发, 段桂玲, 吕 红, 刘 焰, 章丽娟, 梅玉萍, 马丽艳. 茶叶中铅同位素比值的测定方法
[J]. 地球化学, 2005, 34(4): 373-378

[39] Gulson B L, Lee T H, Mizon K J, et al. The application of lead isotope ratios to the determine the contribution of the tin-lead to the lead content of wine
[J]. American Journal of Enology and Viticulture, 1992, 43: 180-190

[40] Rosman K J R, Chisholm W, Jimi S, et al. Lead concentrations and isotopic signatures in vintages of french wine between 1950 and 1991
[J]. Environmental Research, 1998, 78: 161-167

[41] Augagneur S, Medina B, Grousset F. Measurement of lead isotope ratios in wine by ICP-MS and its applications to the determination of lead concentration by isotope dilution
[J]. Fresenius'Journal of Analytical Chemistry, 1997, 357: 1149-1152

[42] Medina B, Augagneur S, Barbaste M, et al. Influence of atmospheric pollution on the lead content of wines
[J]. Food Additives and Contaminants, 2000, 17(6): 435-445

[43] Mihaljevi Dc ˇ M, Ettler V, ebek O, et al. Lead isotopic signatures of wine and vineyard soils-tracers of lead origin
[J]. Journal of Geochemical Exploration, 2006, 88: 130-133

[44] 王 新, 吴燕玉. 不同作物对重金属复合污染物吸收特性的研究
[J]. 农业环境保护, 1998, 17(5): 193-196

[45] Zhao F J, Adams M L, Dumont C, et al. Factors affecting the concentrations of lead in British wheat and barley grain
[J]. Environmental Pollution, 2004, 131: 461-468

[46] Komarek M, Chrastny V, Stichova J. Metal/ metalloid contamination and isotopic composition of lead in edible mushrooms and forest soils originating from a smelting area
[J]. Environment International, 2007, 33: 677-684

[47] Yamac M, Yidiz D, Sarikürkcü C, et al. Heavy metals in some edible mushrooms from the central Anatolia, Turkey
[J]. Food Chemistry, 2007, 103: 263-267

[48] Demirbas A. Accumulation of heavy metals in some edible mushrooms from Turkey
[J]. Food Chemistry, 2000, 68: 415-419

[49] Demirbas A. Concentrations of 21 metals in 18 species of mushrooms growing in the East Black Sea region
[J]. Food Chemistry, 2001, 75: 453-457

[50] Cast C H, Jansen E, Bierling J, et al. Heavy metals in mushrooms and their relationship with soil characteristics
[J]. Chemosphere, 1988, 17 (4): 789-799

[51] Spencer K, Shafer D J, Gauldie R W, et al. Stable lead isotope ratios from distinct anthropogenic sources in fish otoliths: a potential nursery ground stock marker
[J]. Comparative Biochemistry and Physiology, Part A, 2000, 127(3): 273-284

本刊中的类似文章

1．陈殿华.中国辐照食品的产业化发展[J]. 核农学报, 2004,18(02): 81-88

2．汪海燕,徐晓洁,叶庆富.辐照食品检测技术的研究进展[J]. 核农学报, 2004,18(02): 137-141

3． 蔡先峰, 郭波莉, 魏益民, 孙淑敏, 魏帅.基于动物组织器官中稳定性同位素组成变化的溯源研究进展（综述）[J]. 核农学报, 2011,25(2): 302-307

4．杨宗渠,刘伟,朱军,陈海军,党从军,刘克波,尚丙兰.中国加入WTO后河南省食品辐照的发展对策[J]. 核农学报, 2003,17(05): 375-378

5．张世民,傅俊杰,包劲松.超微弱发光分析法在辐照糖类检测中的应用(Ⅰ)[J]. 核农学报, 2003,17(03): 231-232

6．于子厚,王守经,孙守义,邹积万,张志远.山东省农副产品及食品辐照加工现状[J]. 核农学报, 2002,16(03): 191-192

7．单张生,崔登来.电子束辐照食品保鲜的近况和展望[J]. 核农学报, 2001,15(02): 125-128

8．唐年鑫,林若泰,熊光权.辐照畜禽肉类熟食品的工艺研究[J]. 核农学报, 2000,14(06): 375-379

9．陈云堂,张建伟,杨保安,王永.河南省食品辐照贮藏研究综述[J]. 核农学报, 1999,13(02): 0-0

10．赵克俭,万虹,刘天伟.液体食品辐照时的过氧化氢[J]. 核农学报, 1990,4(01): 47-51

11．赵克俭,刘天伟.辐照香料与食品的鉴定[J]. 核农学报, 1989,3(02): 91-97

12． 刘斌, 熊善柏, 熊光权, 程薇, 陈玉霞, 廖涛, 李新, 林若泰.辐照技术在食品污染物控制方面的研究进展[J]. 核农学报, 2010,24(4): 784-789

13． 王 学, 徐恒戬, 刘 涛.白菜对铈、铅胁迫响应的比较研究[J]. 核农学报, 2010,24(3): 634-638

14．赵永富1 李俐俐1 王志东2 汪昌保1 季 萍1 王 超1.直接荧光过滤技术/平板计数法(DEFT/APC)检测辐照食品[J]. 核农学报, 2010,24(5): 1006-1010

15． 韩志萍, 杨志红, 吴湘, 张华.铅胁迫对芦竹抗氧化酶活性的影响[J]. 核农学报, 2010,24(4): 846-850
